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THE PROSPECTS BEFORE BUDDED RUBBER.

In previous numbers of the *Tropical Agriculturist* attention has been drawn to the possibilities before budded rubber and to the necessity for experimental work in this connexion. The different methods of budding have been described and practical demonstrations have been held at various centres.

As the result of these demonstrations a limited number of plants have been budded and planted out, and a somewhat larger number of plants have been budded in the field.

Yield results from various budded areas in Malaya have recently been published and reports of high yields from some areas in Sumatra have recently been received in Ceylon. These reports have given rise to a revival of interest in the possibilities before budded rubber and to a demand for the budding of some of the newly planted rubber areas in the colony.

It was previously urged upon all estates that accurate yield records of the highest yielding trees should be kept and a number of estates have had such records maintained during the past two or three years. Those estates which have such records available now have definite data to work on and can now tackle the question of budding rubber with a certain degree of confidence. Those with no records will find it impossible to progress along sound lines and may be disappointed in the results of their work if budding is attempted.

It has been found in the Dutch East Indies that yield results from budded plants are variable, and a satisfactory explanation of these variations has not yet been offered. Buds taken from some high-yielding trees when budded on to certain

stocks give rise to plants which may all be high yielding but under other conditions yield results which may be little better than the average of a mixed population of seedlings.

It is not certain that buds from a high-yielding mother plant will always give those satisfactory results which are being looked for. Some high yielders may prove to be good mother trees whilst other yielders may prove to give only moderately yielding offspring.

The value of any high-yielding mother tree can only be judged by the actual yield results of its budded offspring and it is quite possible that combinations between certain buds and certain stocks are essential for the greatest success and for the highest yields.

It is therefore essential that all estates which propose to take up budding should secure technical advice in regard to their programmes. Not only must the origin of the buds be known, but the origin of the stocks should also be recorded.

It is correct that certain buddings on stocks of mixed origin have given average yields in excess of seedlings of similar origin, but these are fortuitous chances upon which no estate should wholly depend if other methods are possible. Those estates therefore which have taken steps to prepare themselves for budding work are in a position to begin at once; others which have not made such preparation by means of records of high yielders or by the establishment of stocks of seedlings from known mother trees would be advised to commence this year and prepare for a subsequent budding campaign.

There appears to be little doubt that budding of rubber will play a more and more important part in the future of the estate side of the rubber plantation industry. The amount of rubber being grown by small holders throughout the East and particularly in the Dutch East Indies is increasing enormously and it should always be possible to place this rubber on the market at relatively low costs. Estates therefore which are in a position to look to the future would be wise to examine closely and critically every measure which is calculated to secure high yields from those areas which remain to be opened up.

RUBBER.

REPORT ON RUBBER TAPPING EXPERIMENTS FOR 1925.
EXPERIMENT STATION, PERADENIYA.

THE OLD TWO- VERSUS THREE-DAY TAPPING TRIALS, PLOTS 151-154.

The following are the yields per tree of dry rubber, including scrap, from 1919 to the end of 1925 :—

	TWO-DAY TAPPING				THREE-DAY TAPPING				
Year	Series 1 lb. oz.	Series 3 lb. oz.	Series 5 lb. oz.	Average lb. oz.	Series 2 lb. oz.	Series 4 lb. oz.	Series 6 lb. oz.	Average lb. oz.	Percentage Two-day tapping yields
1919	3 2	3 4	3 4	3 3	2 5	2 4	2 8	2 6	73·6
1920	3 12	3 7	3 7	3 8	2 7	2 10	2 8	2 8	70·9
1921	4 3	4 2	4 5	4 3	2 15	2 12	3 3	2 15	69·6
1922	4 0	4 5	5 1	4 7	3 4	3 5	4 3	3 9	80·3
1923	3 9	4 7	3 13	4 4	1 15	2 6	3 1	2 7	57·5
1924	3 14	4 13	5 6	4 11	3 3	3 2	3 14	3 8	66·6
1925	3 10	3 13	4 5	3 15	2 13	2 11	2 15	2 13	71·2
Total	26 2	28 3	29 9	28 3	18 14	19 2	22 4	20 2	71·5

Since the start of this experiment 13 trees have been lost from *Fomes lignosus* and the balance of the plots has been thus somewhat upset.

The two-day and the three-day tapping blocks are arranged alternately. will be noticed that the yields generally tend to increase in passing from Series 1 to Series 6.

106 inches of rain fell in 1925, against an average of 89 inches, and this accounts for the general decline in yields. The additional decline in the two-day tapping series is due to the change over to the top of a new panel which took place in February 1925. Since in both methods of tapping the cuts are started at the same height from the ground it follows that the relative yields obtained by the two methods will fluctuate according to the distance down the tree that cuts in each method have reached in any particular year. The plan of the experiment has been criticised on these grounds, but it is quite possible that estates adopting three-day tapping might prefer to obtain a 9 years' bark renewal period rather than reduce the height of the panel to be tapped. For this reason these figures are of interest, and over a considerable period a reliable comparison of the two methods can be made.

It is proposed to bring this experiment to a conclusion at the end of 1927 when the present three-day tapping panel will be completed.

A census of diseased trees taken in December 1925 gave the following figures:—

	TWO-DAY TAPPING				THREE-DAY TAPPING			
	Number of trees showing symptoms			Percentage of total No. of tapped trees	Number of trees showing symptoms			Percentage of total No. of tapped trees
	Series 1	Series 3	Series 5		Series 2	Series 4	Series 6	
Brown Bast	3	—	—	3·7%	—	—	—	—
Bark rot	9	1	1	13·3%	3	1	1	5·8%
Canker	3	1	1	6·4%	—	1	—	1·2%

From the disease point of view the three-day tapping appears to have been beneficial.

THE HILL TOP RUBBER.

In this block three experiments are in progress:—

1. Comparison of three methods of planting.
2. Comparison of V cut with single cut.
3. New two- versus three-day tapping trials.

1. In the following table comparison is only made between those trees in each block which are tapped with a single cut on alternate days. Tapping was started in every case on April 7th, 1922.

Block and method of planting.	No. of trees p. acre	*Yield per tree*			*Calculated yields per acre*		
		1925 lb. oz.	Previous lb. oz.	Total to date lb. oz.	1925 lb. oz.	Previous lb. oz.	Total to date lb. oz.
A. Clumps of 4 trees 12 ft. x 15 ft. with between clumps.	69	5 –	11 0	14 0	347	759	1106
B. Avenues. Trees 15 ft. x 12 ft. with 40 ft. between avenues.	112	3 2	6 13	9 15	317	763	1080
C. Square planting 20 ft. x 20 ft.	109	3 9	8 8	12 1	385	899	1284

The soil conditions and lie of the land on which these blocks are planted are not similar : Block A is on gently sloping land, Block B on flat land and Block C on fairly steep and rocky land. The yields therefore are not truly comparable. The yields per tree of the trees widely spaced in clumps in Block A are however rather remarkable : up to the end of 1924 the calculated yield per acre was only 4 lb. behind Block B, now it is well ahead of that Block although there are only 69 trees to the acre compared with 112 in Block B.

It is also noticeable that in this case the rubber on the flat land has given the lowest yield per tree.

The average girth of all the trees in tapping in those blocks are :—

	December 1921 Inches	December 1925 Inches	Increase in 4 years Inches
Block A	28·5	38·5	10
Block B	29·5	37·7	8·2
Block C	27·5	35·6	8·1

The trees planted in widely spaced clumps therefore have shown a greater increase in growth than the trees in either of the other blocks and this increase has been accompanied by a growing superiority in yield per tree.

2. V CUT VERSUS SINGLE CUT.

Half the trees in Blocks A and B are tapped with a V cut and half with a single cut. The angle in both cases is 16°. All cuts are at 24 in. from the ground on the half circumference. Tapping was started on April 7th, 1922.

YIELDS PER TREE

	Single cut			V cut			Average increased yield per tree from V cut
	Block A lb. oz.	Block B lb. oz.	Average lb. oz.	Block A lb. oz.	Block B lb. oz.	Average lb. oz.	
1922 April to December	2 7	1 12	2 1	2 5	1 12	2 0	— 1 oz.
1923	3 11	2 4	3 0	4 0	2 12	3 6	+ 6 „
1924	4 14	2 13	3 13	5 10	3 7	4 8	+ 11 „
1925	5 —	3 2	4 1	5 7	3 10	4 9	+ 8 „
Total	16 —	9 15	12 15	17 6	11 9	14 7	+ 1lb 8 oz.

The first change over was made in April 1925. It is intended to carry on this experiment till the end of 1928 when it should be possible to ascertain definitely whether the method of tapping is influencing the yield.

NEW TWO- VERSUS THREE-DAY TAPPING TRIALS.

Tapping with a single cut at 16° on the half circumference was started on April 7th, 1922. The cuts on the trees tapped every three days were in

this case made at 16 in. from the ground while those on the trees tapped on alternate days were started at 24 in. from the ground. The two cuts therefore reach the bottom of the panel at the same time.

Year	*Two-day tapping*				*Three-day tapping*				
	Series 1 lb. oz.	Series 3 lb. oz.	Series 5 lb. oz.	Average lb. oz.	Series 2 lb. oz.	Series 4 lb. oz.	Series 6 lb. oz.	Average lb. oz.	Percentage of two-day tapping
1922 April to December.	2 2	2 3	1 13	2 1	1 10	1 9	1 9	1 9	75·5
1923	3 0	3 2	2 10	2 15	2 10	2 4	2 10	2 8	85·1
1924	3 6	4 1	3 5	3 9	2 12	2 13	2 15	2 13	79·0
1925	3 6	3 12	3 13	3 10	2 15	2 15	3 1	2 15	81·4
Total	11 14	13 2	11 9	12 3	9 15	9 9	10 3	9 13	80·00

It will be noted that the percentages in the last column are generally higher than those found in the old experiment.

The disease census figures are given below :—

	Two-day tapping				*Three day tapping*			
	Series 1	Series 3	Series 5	Percentage trees affected	Series 2	Series 4	Series 6	Percentage trees affected
Brown Bast	4	1	1	3·6	2	-	-	1·2
Bark rot	3	9	3	8·9	1	3	2	3·6
Canker	5	4	4	7·8	2	2	-	2·3

Here, as in the old experiment, the disease incidence is consistently less in the three-day tapping.

It is intended to carry on this experiment till the end of 1928.

THE HILLSIDE RUBBER.

The experiment here in progress is a comparison between

(1) Tapping on alternate days throughout the year.

(2) Tapping daily in the months of January, March, May, etc.

(3) Tapping daily in the months of February, April, June, etc.

Tapping was started on April 7th, 1922, but the yields for that year are only recorded from May onwards so as to include 4 tapping months from each of the daily tapped blocks.

Alternate days throughout the year				Daily in January, March, May, etc.			Daily in February, April, June, etc.			Average of daily tapped blocks.
Year	Series 1	Series 6	Average	Series 2	Series 4	Average	Series 3	Series 5	Average	
	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
1922 April to December	1 14	1 14	1 14	1 13	2 —	1 14	1 15	1 15	1 15	1 15
1923	3 8	3 —	3 4	3 —	3 3	3 2	2 14	3 —	2 15	3 0
1924	4 1	3 11	3 14	3 9	3 8	3 8	3 13	3 14	3 13	3 11
1925	3 13	3 4	3 9	3 10	3 9	3 9	3 12	3 15	3 13	3 11
Total	13 4	11 13	12 9	12 0	12 4	12 1	12 6	12 12	12 8	12 5

In 1925 for the first time the average yield per tree of the blocks tapped daily in alternate months is slightly in excess of that of the blocks tapped on alternate days. Over the whole period however there would appear to be no significant difference in yield. Fluctuations between the two daily tapped blocks can be generally explained by a study of the rainfall figures. Thus in 1923, in the months in which series 2 and 4 were tapped 48·76 inches of rain fell and the average per tree for those series was 3 lb. 2 oz. against 2 lb. 15 oz. for series 3 and 5 which were tapped in months in which 67·12 inches of rain fell. In 1924 the position is reversed and the rainfall provides the reason—48 91 inches fell during the months in which series 2 and 4 were tapped but only 21·99 inches in the months in which series 3 and 5 were tapped. With regard to disease, in the first year of the experiment it appeared that the incidence of Brown Bast was heavier in the blocks tapped daily in alternate blocks. The latest figures however are not significant, 6·3% of the trees tapped on alternate days are affected with Brown Bast and 8·2% of the trees tapped daily on alternate months.

INDIVIDUAL YIELDS.

Individual yields of dry rubber have been recorded from the trees in plots 11, 12, 13, 14 and 15.

A bulletin on the results on the four years' results from plots 14 and 15 by Mr. R. A. Taylor of the Rubber Research Scheme is now in the press.

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CACAO.

THE CURING OF CACAO.*

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From time immemorial the cacao bean, as removed from the pod, has been cured by one or another of the various methods employed to-day; that is to say, there has been little or no change of methods of curing from those employed in very ancient times, long before science had begun to shed its beneficent light upon so many common procedures: before physiology had given us knowledge of enzymes, or bacteriology knowledge of yeasts, bacteria and fermentation.

To be sure there have been many competent scientific workers who have studied the curing of cacao extensively. Thus, Harrison † of British Guiana made very extensive studies of the chemical changes occurring during fermentation, comparing the chemical content of the beans before and after fermentation. Others have studied the yeasts and bacteria involved in the fermentation process, and some investigators have recommended the use of special species of races of yeasts—much as pure culture 'starters' are now employed in the ripening of cream for the making of butter. Still others have given some attention to the enzymes present and their probable function. In addition to numerous articles by scientists, there are almost innumerable articles by people without scientific training, but who write from their practical experience. Such writings usually are valueless as regards fundamental information, and often valueless as guides to procedure, because the conclusions drawn may be erroneous due to lack of trained observation and reasoning.

A rather comprehensive summary of the status of knowledge regarding cacao fermentation in the year 1908 is given by the eminent plant physiologist Dr. Oscar Loew. ‡ As yet the actual factors important in cacao curing appear to be unknown, since by various authors, differing claims and conclusions are advanced.

By some it is claimed that the organism, yeast or bacterium, that causes the fermentation is of great significance, and the use of one special yeast, *Saccharomyces theobromae*, as an inoculum, has been advocated. So far as I am aware, however, this suggestion has had little or no influence on actual practice. The part that the heat developed in the fermentation plays is uncertain. It is asserted by some that the function of heat is to kill the embryo in order to liberate the enzymes within the seed so that they may act upon the seed constituents.

Much uncertainty and diversity of opinion exists as to the degree of heat that brings best results.

In some countries, *e.g.*, Surinam, a temperature of 45° C is advocated, in others 50°. Hart says that there is danger of injury if the temperature is allowed to rise above 60°, while M. Schulte devised a special fermenter, the purpose of which was to maintain a constant temperature of 60° C.

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* Paper read at the Pan American Scientific Congress, December 22, 1924.

† Harrison, J. B., Proc. Agr. Soc. Trinidad, 2: 250, 1896-7.

‡ Loew, Oscar, The Fermentation of Cacao, Porto Rico Agr. Exp. Sta. Rept. for 1907

As regards the function or purpose of fermentation there is also diversity of opinion.

Loew summarises his view as follows:—

"The chief purposes of the fermentation processes are:

(1) Removal or contraction of the pulp surrounding the seeds,

(2) Loosening of the connection between the seed and its testa

(3) Development of colour and improvement of taste."

Others hold that fermentation hardens the interior of the bean, toughens the seed coat, or develops the aroma.

Just how important each of these functions is, appears to be undetermined, and that some of them are important at all is far from certain.

Excellent beans are produced in some countries without any fermentation, but, in general, the process appears to be a necessary one. If properly carried out, it should result in beans that will not mould (the loss through mould often runs very high), and which possess the best colour and aroma possible with the variety of cacao used.

Perhaps the three most important qualities influenced by fermentation are colour, sourness or acidity, and aroma, different methods of handling the same beans giving results of large diversity in these regards.

Much uncertainty exists as to the various factors that can influence the quality of fermentation, some attaching importance to the quality of the container, whether wood or metal, others to the time of turning the beans, to chilling of the beans at the surface or sides, &c.

So much uncertainty about fermentation leads to such useless thinking, and to uncertain, often erroneous, practice. If some of the erroneous conceptions could be proved to be erroneous, certain factors could be dropped from consideration, and the problem much simplified. An improvement of even a cent a pound on the world crop of cacao would be very significant item.

Last summer my attention was called to certain of the difficulties attendant upon cacao fermentation, and I became interested in the problem from a scientific viewpoint, with the result that I made something over 250 experiments in the laboratories of the University of Illinois on lots of cacao pods kindly supplied to me for this purpose by the United Fruit Company. While these experiments cannot be regarded as final, I report them herewith because I believe the results to be very significant, establishing certain broad fundamental conclusions, and pointing the way to several avenues for future experimentation.

The object of my experiments was mainly two-fold: I. To produce a commercial bean of lighter colour internally than that produced by the ordinary fermentation used by the United Fruit Company: 2. To produce a bean less acid than that produced by the ordinary processes. Both of these have been accomplished, as well as several interesting additional changes.

At the outset of my experiments it appeared probable that three factors were much more significant than others; namely, 1. Heat, 2. Organisms, 3. Enzymes. Without burdening you with the detail of the experiments I will say that the preliminary work showed that if the beans are heated to a temperature sufficient to kill the embryo, but not sufficiently high to destroy

the activity of the enzymes within the embryo, and are then maintained at a suitable temperature and moisture for a proper length of time, a good product is secured. This finding indicated that the first step was to determine accurately: (1) the temperature needed to kill the embryo. (2) the temperature that it is possible to employ without danger of injuring the enzymes.

The Temperature Necessary to kill the Embryo.

My experiments have not been sufficiently extensive to settle this point accurately. Moreover, it is questionable whether results attained on beans from pods shipped from the tropics to Illinois would agree precisely with results of experiments carried out in the tropics. Nevertheless my results may be accepted tentatively as reasonably accurate.

TABLE I.

Temperature and Exposure Required to Kill the Embryo.

Time.	45°	55°	60°	75°
20 min.	alive	dead ?	dead ?	dead
30 min.	alive	dead ?	dead	dead
1 hr.	—	--	-	dead
2 hrs.	dead	dead	dead	—
24 hrs.	dead	dead	dead	—
4 days	dead	dead	—	—

It is thus seen that for 60° C., even a half hour is sufficient to kill the embryo, or that 45° for 24 hours or something less, also kills the embryo. Loew says the " seeds commence to die when the entire fruit is kept for several days at 40° to 45° C."

The Temperature that may be Employed without Injury to the Enzymes.

The same objections to the accuracy of my conclusions can be raised here as in case of the last experiment, but the results are accurate enough to be significant. The tests were made by submitting 100 live beans to the temperature and for the time indicated. The results were read by cutting the seeds open after treatment and exposing them to the air. Those in which the oxidizing enzymes were uninjured soon turned brown; those in which the enzyme was injured did not turn brown.

The results are as follows:—

TABLE II.

Temperature and Exposure Required to Destroy the Oxidizing Enzyme

Minutes.	100°	90°	80°	72°	65°	60°
1	2	1	0	0	0	0
2	50	0	0	0	0	0
3	75	2	0	0	0	0
4	100	100	0	0	0	0
5	100	100	0	0	0	0
6	100	100	1	2	0	0
7	100	100	1	1	0	0
8	100	100	0	0	0	0
9	100	100	0	0	0	0
10	100	100	1	0	0	0

The figures in the above table indicate the number of seeds out of 100 in which the oxidizing enzyme was destroyed.

It is to be noted that even four minutes at 90° destroyed the enzyme in all the seeds, while at 65° even ten minutes destroyed it in none. The 72°

and 80° experiments need repeating and experiments at 65° should be run for longer times. Subsequent experiments showed that the enzymes are not destroyed at 60° for unlimited time.

Loew states that "The killing temperature for oxidases is 20° to 30° C. higher than for protoplasm or living matter," also that the peroxidase in the cacao bean was destroyed at 75° C. for five minutes, thus being in approximate agreement with my results.

The significant point is that there is ample margin between the death temperature point of the embryo and the destruction point of the enzymes.

Having ascertained this, I subjected various lots of live cacao beans to various temperatures below the destruction point of the enzyme, but above the death point of the embryo.

Here I should state that all of these experiments were made employing three galvanized iron tanks about 60 cm. square and 30 cm. deep. These tanks were filled with water kept at a constant level by appropriate apparatus, and were so equipped with electric heaters and controls that the water in them could be kept at any desired temperature for any length of time, with less than one degree of variation. Compressed air was available, so that any variation in the oxygen relation desired could be made. Glass jars, about 15 cm. in diameter and 22 cm. deep, with wooden perforated false bottoms about 3 cm. from the bottoms of the jars, to provide drainage when required, and also to allow the introduction of the compressed air, served to hold the beans in the experiments. In an early experiment temperatures were used which destroyed the enzymes, *e.g.*, boiling for five minutes. Beans so treated, due to the destruction of the enzymes, could not, by any subsequent treatment, be satisfactorily fermented. Under no treatment did they undergo the desired colour change in the embryo, resulting in the tan shades favoured by the market.

Another early experiment was to attempt fermentation, holding the temperature below the death point of the embryo. Similarly these treatments also failed to give the desired results, the only exception being when comparatively low temperatures, *e.g.*: 35–45° C. were allowed to act for several days. Such treatments, however, killed the embryo, though slowly.

The results of these preliminary experiments appear therefore to establish two points.

1. The embryo must be killed to permit the enzyme to oxidize the embryo to the proper colour.

2. The heat must be lower than that which would destroy the activity of the enzymes.

The next step was to determine the most favourable temperature for enzyme action after the embryo has been killed as above indicated. Experiments were then set up according to the following tabulation.

Plan of Experiments on Temperature and Time.

40°	45°	55°	60°	80°
20 min.	20 min.	20 min.	20 min.	20 min.
2 hrs.	2 hrs.	2 hrs.	2 hrs.	2 hrs.
3 days	3 days	3 days	3 days	3 days
9 days	9 days	9 days	9 days	9 days

As was to be expected none of the short time treatments, 20 minutes or 2 hours, showed any oxidation of the enzymes. They were like raw beans, because the time interval was too short to permit the enzymes to act. All four of the 8[0] treatments resulted alike; no oxidation—because the enzyme was destroyed.

The lots of beans subjected to 40°, 45°, 55° and 60° for 3 days or nine days all showed proper oxidation of the embryo. Further experiments were made to determine more exactly the most favourable time and the most favourable temperature, but they will not be cited here because they should be verified in the tropics.

The general fundamental conclusion stands out, however, that temperatures from 40° to 60° C. for several days, killing the embryo without destroying the enzyme, result in the desired colour changes in the embryo.

In all of these experiments the beans were handled carefully to avoid bacterial contamination, so that but few bacteria or yeasts were present; indeed, at 45°, 55° and 60°, they could not grow anyway. Therefore the colour changes secured in these experiments were due to heat, and in no way to bacteria or yeasts. It therefore appears that the one essential thing is to kill the embryo and allow the enzyme to act. The essential process is therefore not a fermentation at all.

Acidity or sourness in the final product is one quality that reduces the value of the bean as much, or more so, than does lack of proper colour. Much has been written about acidity and many are the causes to which it is attributed. Acidity was markedly absent from the samples produced by the above-cited experiments. So much superior were they to commercial beans sent to me by the United Fruit Company from their "regular run" and made from raw beans of the same quality that Allegretti's cacao buyer priced them at a much higher figure varying from one to three cents a pound due to their superior colour, aroma and lack of acidity.

Samples of these beans were shipped by me to the Costa Rican division of the United Fruit Company and the reply of their Manager there reads "to say that we are delighted with the wonderful progress you have made is putting it mildly indeed."

To ascertain whether bacteria or yeasts alter the quality of the product, beans were killed by heat and inoculated with pure cultures of various organisms. Many organisms were employed, particularly organisms known to produce aromatic or other distinctive flavours. Among those used were vinegar yeasts, vinegar bacteria, lactic acid bacteria, distillers' yeast, and *Bacillus gasoformans*. The beans, inoculated with these, were incubated at 37° for several days.

The colour changes due to the enzymes had proceeded normally but in addition, due to the organism, various effects in aroma, taste and particularly in acidity were noted.

It thus appears that the germs growing in the fermenting mass, produced chemicals that can penetrate into the beans and change their qualities. None was noted that gave any beneficial effect. Such, however, may exist. Many were noted that gave injurious effects, and many that increased acidity. It appears to me probable that the undesirable acidity of commercial beans is due to micro-organisms in the fermenting mass and that these micro-organisms are entirely unneeded. In commercial plants, as at present conducted, the heat to kill the embryo is produced by organisms, mainly bacteria, partly yeasts, which ferment the beans. In so doing the beans on top, below, in the interior and at the sides, are at different temperatures, which differences are equalized partially by turning the bean mass. The temperature is low enough to allow the organisms to grow and acids are produced and absorbed.

Though further work should be done, studying pure cultures of yeasts and bacteria, in the search for one that will improve aroma or taste, I believe that I have shown that acidity is due to the fermentation organisms, and that the surest way to secure proper colour and absence of acidity is to eliminate the germs by heat and let the enzymes do the rest.

In studying methods of applying the heat I tried two ways: first killing the embryo by immersing the beans in hot water.

1. In water.

Beans were placed in the experimental jars, covered with water, and placed in the tanks.

2. With no water.

Beans were placed in the jars as above but no water was added.

In both cases the colour changes occurred properly with no development of acidity.

Experiments were also made parallel to those given above with the exception that air was forced continuously through the mass of beans. The introduction of the air appeared to hasten oxidation somewhat, but not sufficiently to be significant.

My final conclusions are: 1. That acidity can be avoided by avoiding bacteria and yeast. 2. The embryo must be killed by heat. 3. That the oxidizing enzymes must be uninjured. 4. That the oxidation can proceed in water as well as without. I believe that all of this can best be accomplished by killing the embryos by artificial heat, by immersing the beans in water in a tank equipped with steam coils. This would result in a saving of several days over the present method of killing the embryos by heat of fermentation. After killing the embryo by heat two lines of procedure are open.

1. To keep them in 60° water until the enzymes have had sufficient opportunity to act, or

2. To drain off the water, or place them in tanks without water, still maintaining a temperature above that at which germs thrive but below the destruction point of the enzymes.

Processes and machinery which involve all of these ideas can readily be devised and adapted to the needs of the large producer or of the small planter.

Very large losses through deductions in price are incurred in the markets due to mouldy beans. Beans treated as I have outlined above will not mould if stored under proper conditions.

There is one other point about cacao that I wish to mention, that is regarding the degree of maturity of the pods. Tests using some accurately controlled devices, such as I have mentioned, should be made on different varieties of cacao, and particularly on cacao of different degrees of maturity. Comparing these under standard conditions, it might be found that different varieties require somewhat different temperatures in curing. It is also reasonable to expect that there is a certain degree of maturity which would yield the best product. If too immature, perhaps the oxidizing enzymes are not yet present in sufficient quantity; if too mature, perhaps they have deteriorated. The proper degree of ripeness of pod should be ascertained for each variety. This alone might lead to a very appreciable increase in the value of the product.—Bulletin of the Department of Agriculture, Trinidad and Tobago, Vol. XXI, Part I.

PESTS AND DISEASES.

RED RING DISEASE OF THE COCONUT.

S. F. ASHBY, B.Sc.

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The following paper on " Red Ring Disease of the Coconut " by S. F. Ashby, B.Sc., together with the discussion thereon, are taken from the *Proceedings of the Ninth West Indian Agricultural Conference*, Jamaica, 1924 :—

This is a fatal parasitic infectious disease recently recognised as of wide distribution in the West Indian Region but known for nearly 20 years under the name of root disease in Trinidad and Tobago. It is present in Honduras, British Honduras, Panama, Venezuela, British Guiana, Trinidad and Tobago, Grenada and St. Vincent but has not yet been definitely reported from the Greater Antilles. The evidence suggests spread by means of seed nuts so that it may have been introduced already from Central America into one or more of the Greater Antilles. Coconut planters in Jamaica should therefore be acquainted with the symptoms and the nature of the parasite.

It is characteristic of the disease that trees approaching bearing age or recently come into bearing are most subject under plantation conditions and that after causing losses for a few years the attack may wear off. It is therefore usually in the 4th or 5th year that the early cases may be looked for and after increasing in number for two or three more years, there may be a gradual or rapid falling off of fresh cases by the 9th or 10th year. Before the disease abates the loss of trees may amount to or exceed 30 per cent. in Trinidad or Tobago.

Symptoms of the Disease as described by Nowell and seen by the Writer in Grenada and Trinidad.

External Symptoms.—The first indications in trees already in bearing are the shedding of green nuts in all stages of development and withering of opened or unopened inflorescences. There follows a progressive yellowing and browning of the leaves from below upwards beginning at the tips, involving finally leaves not yet fully expanded. The oldest leaves may however not be the first affected. The leaves eventually give way and hang down or break 1-2 feet above the base. If the tree is allowed to stand the heart leaves wither and the central column falls over.

These symptoms resemble closely those associated with the form of budrot attributed to bacteria and as a fact in both Red Ring and Budrot the final condition is a soft stinking rot of the bud.

Internal Symptoms.—These are quite characteristic and distinguish the disease at once from any form of bud-rot infection or otherwise.

In the stem there is a continuous dull red ring, 1-1½ inches wide, and 1-2 inches from the surface extending upwards from the base to a height of 4 feet or more, and then breaking into red streaks and scattered red dots up into the tender tissue below the growing point. In rare cases where the young leaves are the first to fall, the red zone may be central in the stem.

The leaves when split lengthways through the middle of the stalks show a dull red or sulphur yellow streaking and mottling from the base for 6 inches to 2½ feet, and this may be present even in young leaves which are still fully green.

The internal streaking and mottling in the leafstalks is often succeeded and marked by a diffuse wet brown rot of secondary origin, due usually to the common saprophyte *Diplodia theobromae*. It is doubtless the cause of the leaves hanging down or breaking across in the stalks.

The roots may be affected to a very variable degree. When diseased the normally moist white spongy tissue between the hard rind and the central strand becomes dry and flaky, and discoloured yellow to reddish brown.

Cause of Red Ring.

If a fresh scrap of the affected tissue from stem, leaf, stalk or root is teased up in a drop of water and magnified 20 to 50 times, eelworms, frequently in active motion, can be seen. Eggs, larvae of various sizes and fully grown male and female individuals can be found together especially in the stem and leafstalks, but less frequently in the roots. This eelworm or nematode, therefore, breeds freely in the ground tissues of the tree, moving in the intercellular air spaces and puncturing the cells with a delicate spear protruded from the mouth which sucks up the escaping sap. The fully grown males and females are about ½ mm. in length and only 1/140th mm. in breadth. The larvae depending on age vary in breadth from 1/8 to 1/3 of a mm. The eggs straight or slightly sausage-shaped are about 1/24th of a mm. in length and 1/140th of a mm. broad. The worm therefore looks like a flexible needle when in motion.

Mr. Nowell, who was the first to observe the association of the nematode with the characteristic symptoms of the disease in 1917 in Grenada, found it present in all cases seen subsequently in Grenada, Trinidad and Tobago, and his findings have been confirmed by investigators in Central America. As the roots are not always affected and the red zone in the stem is a constant feature of pronounced attack he proposed to substitute " Red Ring " for the older less appropriate name " Root Disease," and his suggestion has been adopted generally.

Infection Experiments.

The first cases seen by Nowell in Grenada were on a Government plot of 68 trees planted in 1912 at Westerhall. Deaths from disease on this plot had begun about 1916 in trees planted 4 years before. In 1919, inoculation experiments were carried out on healthy looking trees (1) by inserting fragments of tissue taken from the red ring in a diseased tree into auger holes in the stems 1-2 feet above the ground, the holes being closed with tarred plugs of deal. After 60 days the three inoculated trees were felled and cut up, and were found fully infested with the nematode in stem, leafstalks and heart, with a pronounced red ring from the base to the bud. Adjacent trees remained healthy.

(2) By dropping fragments of diseased tissue 1-2 inches long and of similar origin into the crown without wounding. After 74 days the nuts on one tree had been shed and the leaves were yellowing and turning brown. All the leafstalks were infested by the worm and the red ring in the stem was pronounced from the base to a height of 8 feet.

Another tree which had only one fragment dropped among the young leaves was examined also after 74 days. Twelve leafstalks were found to be internally discoloured and infested by the worm.

You will note that when the inoculation was made near the base of the stem the worm worked up internally into the leafstalk and that when infected tissue was introduced into the crown, the worm entered the tree and worked down to the base of the stem; the trees were practically dead in 2-2½ months.

In 1921 I had some further inoculation experiments begun on the Westerhall Plot. Bags containing 5 pounds of salt were put above the heart of 8 trees now 9 years old and infested fragments of tissue were dropped into the crowns after 2 weeks. Two and a half months later all the trees were showing marked external symptoms of disease and were cut down and examined.

Two showed full infestation in leafstalks, stem and roots. Four were infested in the leafstalks and upper parts of the stem, which were internally of normal colour and free from the worm to a height of 2, 6, 7 and 8 feet from the ground, respectively. All four, however, were infested in the roots. In the remaining two trees the red ring was very faint in the stems 9 and 18 inches above the ground and no diseased roots were found. In half the trees there had been an infection at both ends—crown and roots, but the worm had not entered the stems from the roots. In two trees no independent infection of the roots had occurred and as the worm and red ring had not quite reached the base of the stems the roots were still sound. The salt drip had evidently neither prevented nor delayed infection in the crowns.

In another experiment begun at the same time infected pieces of stem tissue from a diseased tree were buried in the soil to a depth of 2 inches in a circle 18 inches from the stems of 16 healthy-looking trees. Salt was mixed with the soil round 8 of these trees. After 5 months ten of the trees showed suspicious external symptoms and these were cut down and examined during the succeeding six weeks. All were found fully infested by the worm in roots, stems, and leafstalks, and all showed a well developed red ring. Of the remaining six trees five were infested in the roots but borings at a height of 6 feet gave negative results. Two of these trees died from the disease about 6 months later; the other four are still alive. The most obvious inference is that the ten trees became infected in the roots by the nematodes escaping from the buried fragments of infected tissue and that the worms entered and worked up the stems from the infected roots. This conclusion was not quite established as the trees were not fully infected when cut down, moreover, a severe storm two months after the experiment was begun, injured the tops and rendered them attractive to palm weevils which in Central America have been observed to carry living worms on their snouts. I have been told by a mycologist who has studied Red Ring in Central America that he had cut down apparently healthy trees in badly infected plantations and found the red ring only in the basal part of the stem evidently due to infection through the roots. Salting the soil proved ineffective. At Westerhall 3 trees planted 2 years, and one planted 11 months were inoculated by dropping infected stem fragments among the leaves. After 2-2½ months all showed marked external signs of disease and were found to be fully infested. During the last two years several more 2-year-old supplies on the plot have

died from Red Ring. Although as a rule the earliest cases on plantations do not show under four years, it is evident that younger trees can be infected and killed. In co-operation with Mr. R. O. Williams, at that time Agricultural Superintendent in Grenada, I inoculated full-sized green nuts by inserting an infected fragment into each husk. After 26 days the nuts were examined and found to show a distinct red ring halfway between rind and shell and a darker zone in contact with the shell. The nematodes were abundantly present in both zones. Although the worm has not been found in the husks of coconuts on diseased trees the result of this experiment indicates that nuts which have dropped may be infested from the soil through wounds in the husks, and the worm may multiply in the husks provided the tissue is still sappy. The larvae are very sensitive to desiccation when dried naked on grass and exposed to the air, losing their vitality in a day. It is probable that like a number of pathogenic bacteria and fungi they, especially the eggs, may withstand desiccation for a relatively long period when dried gradually in a vegetable tissue like coconut husk. In Trinidad Red Ring has appeared on young cultivations on land cleared from forest and far removed from infested plantations; these outbreaks seem to point to infection carried in the husks of seed-nuts. The disease has been present in Tobago for many years and was probably introduced into Grenada and St. Vincent in seed-nuts from that island. The disease is apparently endemic in parts of Central America and seed-nuts from there, unless from plantations definitely known to be free from Red Ring, should be regarded with strong suspicion. Two seedlings taken from the nursery at the Botanic Station in Grenada were inoculated in the husks and replanted in pots. After three months several roots on each were infested and the worm was breeding in them, but the plants were quite sound in the stem and leaves. Some experiments are now in progress at Westerhall to determine whether seedlings inoculated in the husks when planted out become infected in the roots and how long this infection can continue before trees become perceptibly diseased. It is possible that the nematode may maintain itself in some of the roots of seedlings for several years before infesting the stems and leafstalks and killing the trees.

There is evidence at Westerhall and elsewhere that the disease can spread from tree to tree, but the problem of just how this occurs and the place on the tree where entrance is most liable to be effected have not yet been solved. It is safe to assume that the great breeding ground of the worm is in the ground tissues of the living tree especially the stem and that it is of great importance that the early cases be promptly detected and thoroughly dealt with. These may be quite few in number in a plantation so that vigorous action may be effective in stamping out the disease before it makes headway. The external symptoms in the leaves will arouse suspicion and a boring or some chops with a cutlass into the stem to a depth of about 3 inches 2 or 3 feet above the ground level will confirm it. As a rule, the tree will be fully infested and should be completely destroyed by fire. A method which has worked well at Westerhall is to dig up the tree, chop up the stem and leaves into short sections, and pile them into the hole, start a fire with the dry trash and cover with earth so that the material will burn slowly for several days, as in the method of burning charcoal.

Nowell has observed that in some plantations which are trenched between the rows the disease has been found to follow along the row without crossing the trenches. This suggests that the spread of infection in the rows might be sufficiently controlled by isolating the infected spot with cross trenches after burning the diseased tree and as an additional precaution isolating the adjacent trees on each side by further cross trenches.

In conclusion, I may say that a well illustrated account of Red Ring can be found in Nowell's recently published book " Diseases of Crop Plants in the Lesser Antilles," which should be in the hands of every progressive planter in the West Indies.

RED RING LITERATURE.

Nowell, W.		
West Indian Bulletin	Vol. 17, p.p.	189—210
do do	Vol. 18 ,,	73— 76
Agricultural News	Vol. 17 ,,	398
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Ashby, S. F.		
Agricultural News	Vol. 20, p.p.	334 & 350
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Cobb, N. A.		
West Indian Bulletin	Vol. 17, p.p.	210

Nowell, W.

Diseases of Crop Plants in the Lesser Antilles.—London, 1923.

I may say this is a book by Mr. Nowell on this disease, which deals with the subject very completely and comprehensively. It is also profusely illustrated and should be in the hands of every practical planter and agricultural officer. It is sold at 12/6, and at the price is one of the cheapest books on the market, and should be in the hands of a very large number of people interested in coconut planting.

Sir Francis Watts: Mr. Nowell, will you supplement Mr. Ashby's remarks.

Mr. Nowell: Mr. President, ladies and gentlemen, I have very little indeed to add to the admirable account of Red Ring disease given to us by Professor Ashby. There are certain points of detail on which one might discourse, but such discourse would be hardly interesting to the general Conference. But I think perhaps it is necessary that I should make one or two general remarks regarding the incidence of the disease, so that if you see it in Jamaica as you probably will sooner or later, you will know how much or how little you will have to fear. Our experience in Trinidad of this disease is now rather lengthy and fairly advanced. It is a disease of adolescence in coconuts. I have met planters whose estates were aged 7 or 8 years, and where they had this disease, and they told me they would be very glad to sell the whole of their trees at Re. 1 a piece and get out of it: I met these same planters a couple of years later, and they put the price of their trees at $ 5 each, the reason being that at the time they looked like losing the whole of their cultivation we found the cause of the trouble. The difficulty, and it is a real one, is that there is very little exterior evidence of the cause of the infection in its early stages. In the meantime you may have lost 30 per

cent. of your coconuts, and you do not know how many of the seedlings you put in are going to succumb in their turn. We have not got sufficient data in Trinidad to make any definite pronouncement on the subject. The point I want to emphasise is that not only is there no cure for it, but I have no hope that any cure will ever be found. I know it is said that experiments have been made of injecting Thymol into trees, like they do for hookworm, and it is claimed, with good results. But I do not think the use of Thymol as a cure will be practical for the reason that you do not know a tree is sick until it dies, or it is at a stage just previous to death. External signs do not appear until the tree is doomed, or already dead, then the red ring is found in all such trees. When the first case is found, it is my experience that it is very far gone indeed. You plant your field, and four or five years later you find just one plant here and there, perhaps widely scattered, showing symptoms of this disease. The evidence all goes to show that these are cases which arose from the original case, but not from a progressive development of the original infection. What I mean is, you get these spasmodic cases continuing the infection. Then you go further, you get one plot infected, and then another, and then you have this 30 per cent. loss, which is very largely a matter of second infection from the few cases that first arose. It is obvious if you are going to meet with this loss, that it will certainly pay to dig up all the trees in the infected area, and make a charcoal pit of them, rather than being merely content at chopping down the infected trees, and saying you can do nothing more. It is the height of economy to spend any money necessary to deal with the first cases, and get them very thoroughly destroyed, because you are combating not only that original infection, but all cases that would eventually arise from it. The only safe criterion for diagnosing red ring disease is the presence of the red ring. There are other appearances, which while quite characteristic, are also shared by other coconut diseases. In Trinidad, I myself would never dare to diagnose a case as being Red Ring unless I had actual facts, and the characteristic effects produced by the disease. Once this is seen, you cannot fail to know the disease. Professor Ashby has mentioned the matter of infection, and its introduction. This is very difficult to trace. It is no easy matter to find, owing to its surroundings, an animal that measures a millimetre in length and very much less in width. It is very difficult to determine and state positively, how infection was introduced in Trinidad, but the general evidence points to outside causes—that the infection was imported. The remedy for this would be to prohibit importation. There is another alternative known as disinfection, but I think it may be stated with a considerable amount of truth that while we all recognise the measure of protection we get from spraying, it has to be thoroughly done before they would probably be quite safe as regards infection. So that if it were desirous to introduce in Jamaica from outside sources a very desirable kind of coconut, you have to be quite certain the spraying is done by a responsible person. Of course, if when the coconuts were taken from the tree they did not rest on the ground, that would probably be an effective method, but at the same time the risk of getting in a trouble you have not already got in is so great that in my opinion such introduction should only be made under the care of the Department of Agriculture, and under very careful conditions even then. Red Ring disease, as I have pointed out, is one of the most serious diseases that the coconut planter has to face; most of the great loss of money it has caused to the estates of Trinidad

and other places is due to the neglect of fairly simple and obvious precautions that could have been taken. I do not think the disease is one which compares with other troubles, which face the coconut planter, such as the Red Rot, which really are very serious for the simple reason that we have not yet found out how they are caused, and therefore cannot take any rational precautions for their prevention. Another method of precaution was alluded to by Mr. Ashby, and I think it is quite sound—the method of trenching. I have noticed in Tobago, where the trees are down with Red Ring that the diseases always progress in straight lines. On the last occasion when I was in Tobago a few months ago, I noticed there were 18 trees that had it in a row, but there was no evidence of the disease on either side of the trench. It does not appear, that trenching, particularly in a serious patch, at any rate, is an effective method of checking the disease. The place at which infection take effect, I find it rather difficult to accept what Professor Ashby has said with regard to root infection. I have carried out a large number of injections in the tops, with the result that the infected plants had died immediately. It was just the reverse with infections in roots. While I have never failed to get infection through the roots, the experiments I have carried out on a good many trees, getting infection through the roots, have failed to produce the death of the tree. The roots were infected, but the infection had not progressed in the tree to the top. Another point that makes me doubtful about root infection, is that trees escape infection once they get beyond a certain height. If infection took place by roots I see no reason why a tree 30 feet high should be any more immune than one 5 feet high. My experience is that the taller the tree the less chance of infection, while if it was communicated through the roots height would make no difference. There are, however, several points in the matter which need to be cleared up, and I hope you will not be scared about this disease, but will be able to give it a rational reception should it ever arrive in Jamaica.

MR. H. H. COUSINS: I think it might comfort our friends in Jamaica to realise that the Government of the country have absolutely prohibited the introduction of coconuts into Jamaica, and it can only be done by the special intervention of His Excellency the Governor. And so long as I act as his adviser I will see that no coconuts shall be admitted here, however desirable they may appear to be. We prefer to stick to our own coconuts and do the best we can with them.

SIR FRANCIS WATTS: Does any one want to ask any further questions about this disease, which is gradually spreading in the West Indies? So far, it would seem that Jamaica is free from it, but it would be unwise after our experience with the budrot disease that we should leave any precautions untaken. As both speakers have stated, it is one of the easiest diseases to diagnose and recognise. The strange thing is that for years it could defy investigations in Trinidad, while continuing to spread. No clear and correct diagnosis was made until Mr. Nowell found out what it was, and then it was wide-spread in the islands and also very widely in Central America. Immense areas in Central America are devastated by the disease which remained unknown until found out by Mr. Nowell, who has rendered a big service to science in this connection. He has told you that once a tree is attacked there is no cure for it. It is no good attempting to treat that tree—to save it. If a tree is found infected, at whatever stage the infection may

be, it should be cut down and burnt at once. I should like Professor Nowell to tell us something more of the rate of infection, and virulence, and in addition, if he has found the disease in other things than coconut palms—if he has found the existence of the minute organisms in other things than the coconut palm. In view of what has been said about this disease of Red Ring, I would strongly advise all interested in coconuts to examine every suspicious case where the appearances are Bud Rot, and bore a hole with an auger to see whether it is not Red Ring. It is most easily diagnosed.

MR. NOWELL: I have not got the exact details in my possession, or any memory of the incidence of the disease in its relation to certain of the palms. I carried out experiments a few months ago at the experimental station at Trinidad with the Gru Gru Palm, and the Cabbage Palm. In the Cabbage Palm the results were so remarkable, that I do not believe them even yet, although I have the figures duly filed, and I made the experiments myself. We had young trees growing, forming an avenue at St. Clair Experimental Station, with no suspicion whatever of Red Ring. The height of some was 8 to 10 feet, at which size the Cabbage Palm tissue is very soft and spongy, and offers a very suitable medium for the development of disease. I introduced small sections of Red Ring into the trunks and in less than three weeks the zone of infection had spread from top to bottom, and some of the palms were absolutely moribund if not quite dead all the way. The ring had a diameter of 18 inches at the bottom and 6 inches at the top and was 8 feet long; each fragment was so fully infected that when placed under a microscope it appeared as if you were looking at a basket of eels. Then the rate of growth was so phenomenal that I can hardly believe it yet. The Gru Gru Palm which is very much harder, gave no such striking results. The trees were 30 feet high, and it took 8 weeks before the infection reached from the base where the injections were made, to the top of the palm. But even that is extraordinary, when you consider the hardness of the stem of that palm. One or two other palms I have tried have shown no evidence of infection. But I have proved that other palms besides the coconut can be infected, and it may be that this disease is a native of some other palm in Central America, and has been distributed on the seeds of the coconut, and has found in the coconut a suitable host.

SIR FRANCIS WATTS: We have on the agenda a general discussion on the coconut industry. Does any one wish to say anything on that head? I don't know if any one wishes to speak on the subject generally or not.

MR. MURRAY: I would like to ask a question with regard to Red Ring disease. I would like to ascertain if there is any discolouration of the stalk by which it can be ascertained, or if the disease is only to be found in the inside tissues.

MR. NOWELL: The answer is no. There are no external symptoms, nothing external by which the disease can be indicated. The heart leaves are generally so discoloured by other parasites, that this minute animal cannot be seen, and even this is no guide, for sometimes the leaves are not infected, while at the same time the inside of the trunk is fully infected.

SIR FRANCIS WATTS: Is there to be no other discussion in regard to other aspects of the coconuts? We have only dealt with one aspect of the diseases of coconut. If there are no further observations then I will ask Professor Ashby to give us his observations on "Wither Tip of Limes."

DISEASES OF COCONUT PALMS.

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The present position of the problem of Palm Diseases is much advanced compared with the position some six years back. Even to-day the position is not altogether clear, but the main cause of the past obscurity has been fairly well eliminated and as a result, investigators on Palm Diseases can get at close grips with the varied symptoms which have to be connected up with definite causes. The study of Palm diseases is of the utmost importance in connection with the development of Malayan Oil-Palm plantations; it is the writer's intention to give a resume of the diverse diseases which have claimed notice in Malaya, at the same time calling attention to the important researches made in other countries.

Bud-Rot of Coconut Palms.

All planters interested in Palm cultivation have come in contact with "Bud-Rot." "Bud-Rot" is a classical instance of an epidemic disease and some writers state that "Bud-Rot" attacks have been so severe in many places that Coconut palm growing has been practically destroyed. The cause of Coconut Bud-Rot, after the investigations of Johnson (2) in the West Indies was attributed to *Bacillus coli* (Escherlich, Migula). Later investigations in India by Butler (1) proved that *Phytophthora palmivora* caused a Bud-Rot of Palmyra palms (*Borassus flabellifer* Linn.); this work was followed up by Shaw and Sundaraman (6) who obtained evidence which led them to the conclusion that *Phytophthora palmivora* was the cause of Bud-Rot in Coconut palms; Reinking (4) in the Philippines came to a similar conclusion, but considered the causal fungus to be *Phytophthora faberi*. The work in India has been followed up and Mc. Rae (3) published a striking article giving the methods and results of the work of the Indian investigators over a period of many years. The conclusions and methods of organising the control work are so interesting as to justify the reprinting of portions of the article.

The position with reference to the Bud-Rot problem in the Eastern Hemisphere has now been soundly stated; investigators in the West Indies, *i.e.*, Ashby, Nowell, and others, have followed up the lines indicated and shown that *Phytophthora palmivora* Butl. is commonly associated with Bud-Rot of Coconut Palms; the position from practically all the large Coconut growing countries has been stabilised and *Phytophthora palmivora* Butl. or some closely related species must be considered the cause of Coconut Bud-Rot.

It should be mentioned that to the layman "Bud-Rot" is a very comprehensive term, for any cause interfering with vital processes usually lays the Bud open to attack, without the necessary entry of *Phytophthora palmivora*; in the writer's opinion there is no doubt that, in the past, many symptoms have been dubbed "Bud-Rot" without due consideration. The position is better understood to-day, and investigators are aware that all obscure symptoms cannot be assigned to "Bud-Rot," simply because the central leaves fall out easily with an accompanying putrefaction of the bud tissue.

Mr. Rae's publication mentioned above is divided into two parts: Part I details operations undertaken to combat the spread of Bud-Rot on Palmyra palms (*Borassus flabellifer*); Part II includes inoculation experiments which prove definitely that Coconut palms can be attacked by *Phytophthora palmivora* Butl.

The clear exposition of the work carried out in India enables one to judge the position in Malaya much more accurately. Mc. Rae proves that although " Bud-Rot " of Palmyra Palms is a serious epidemic disease it can be controlled by systematic measures; that comparatively, Coconut palms, in a badly infected area of Palmyra palms, show relative freedom from the disease. The relative freedom of Coconut palms with regard to attacks of *Phytophthora palmivora*, as compared with Palmyra palms is ascribed to (a) structural differences, (b) less handling of the palms. With reference to the latter, Palmyra Palms in India are largely used for toddy gathering; in Malaya Coconut palms are used exclusively for this purpose, yet there is little difference in this country as regards amount of Bud-Rot to be found on palms used for toddy gathering, and those from which nuts are gathered for Copra. Structural differences are undoubtedly of large significance, as regards comparative freedom of Coconut Palms.

The writer (2) criticising the value of evidence published in papers on ' Bud-Rot ' stated as regards the cause in India " that *Phytophthora palmivora* might be assumed to be the deciding factor in any epidemic of ' Bud-Rot ' though this must be proved by inoculations on mature trees." In this respect the publication by Mc. Rae is complete, and no further doubt can exist as to the primary factor which has to be controlled in Bud-Rot epidemics.

The position in Malaya can be gauged from Mc. Rae's statements— " On Palmyra palms in India ' Bud-Rot ' is a serious epidemic disease which spreads slowly but can be controlled by systematic measures. Coconut Palms, in districts where the causal fungus is present, are relatively free from attacks by the fungus." These conclusions lead to the position that in Malaya " Bud-Rot " of Palms need not be considered a great menace to Coconut and African Oil Palm cultivation, as has been usually understood previously.

As pointed out in (2) the writer is fairly certain that most of the so-called Bud-Rot in Malayan plantations can be ascribed to agencies other than attacks by *Phytophthora palmivora*. This is well seen on mature African Oil Palms; on these palms some form of " Bud-Rot " is common, but the palms practically always recover. Over a period of three years there has only been one casualty, the rot travelling down the stem and so preventing the ascent of water. In previous years several groups of mature trees were taken out annually and destroyed.

With reference to the systematic position of the presumably different *Phytophthora* species suggested as the cause of Bud-Rot of Coconuts, Reinking (4) considered *Phytophthora faberi*. Maublanc, as the cause; in 1924 C. M. Tucker at the Porto Rico Agricultural Station considers this infectious disease as caused by a fungus which has been described as a strain of *Phytophthorn faberi*. Maublanc. Recently the writer had the opportunity of meeting Dr. Reinking who, in turn, had been in communication with Dr. Butler. The conclusion has now been reached that the fungus named

Phytophthora palmivora by Dr. Butler, and that isolated from Bud-Rot in the Philippines and considered by Dr. Reinking as *Phytophthora faberi* are practically identical, so that there is a common cause for " Bud-Rot " in both Eastern and Western Hemispheres.

The following general review of the operations in India is extracted from Mr. Rae's article.

General Review of the Operations (in India).

(a) *The Numbers.*—The earliest attempt in 1906 to deal with the disease over a limited area accounted for 40,000 dead palms. The number of dead palms cut during the 19 months, June, 1907 to December, 1908, viz., 398,000 included many trees that had died from about June, 1904, because it takes up to three years for all the leaves to wither, reckoning from the time the growing-point dies and the topmost leaf has withered. Consequently a considerable number of such cases would still be standing and be dealt with by the staff as they moved over the infected area. As mentioned on page 47, the intensity of the disease was greatest in 1908 when probably about 100,000 died, even though 183,000 were actually cut that year, the excess being cases that had died in the years immediately preceding. From 1908 to 1913 there was not much of a fall in the annual figures this being due to the gradual perfecting of the operations, to trees being cut more promptly and to the area being better patrolled. From 1914 to 1917 there was a steady fall in the number of outwardly diseased and dead trees owing to the fact of 74,800 inwardly infected trees having been dealt with and cured. 1918 was a disappointing year because the number suddenly rose in all categories. However, there was a considerable fall in 1919. In 1920 the Pest Act was applied and the numbers again fell both in that year and in 1921 the last year of the operations under review. From 1913 onwards 100,000 diseased trees in the early stages of infection had the diseased tissue removed and were restored to health during the examination of 2,800,000 apparently healthy palms growing in the vicinity of dead ones, and there can be no doubt that this had a great influence in quickly reducing the number of dead palms in the later years of the operations.

(b) *The Area.*—The area said to have been infected in the earlier years was given by Dr. Butler for August, 1905 * and for the end of 1908, † and in a report to Government I gave the known infected area about the middle of 1910. The diagram ‡ shows in colour the different areas which were about 500, 1,200 and 1,800 square miles respectively. The extension in the Northern part is fairly accurate but that towards the Kistna is inadequate in all three estimates. The information in the earlier estimates was got chiefly by a young member of the Agricultural Department whose home was in the Godavari delta, and it is likely that he had more detailed information about the Godavari where his home and his work were than about the Kistna District. The people in Tanuku and Narasapur Taluqs say they noticed it in 1903, the year of the cyclone, but the people beyond the Narasapur canal had no reason to report the presence of disease in those early days, thus it could only be located by actually seeing it and there was little or no touring done in the Kistna District before 1910 with the object of finding the

* Butler, E.J. Agri. Jour. India, Vol. I pl. XX, p. 305

† Butler, E.J. l.c.

‡ Not reproduced.

extension of the disease. With later more accurate and detailed knowledge of the disease in this locality it seems more than probable that long before 1905 the disease had already crossed the Vasishta branch of the river, and that it had extended further into Kistna District by 1908 or by 1910 than is shown in the map. Early in 1910 cuttings were being made in Bunder Taluq around Masulipatam and from observations on the dead palms there I am certain the disease had been there for over three years before this date. Yet at the end of 1908 the disease had not been reported, nor was it known to exist there, by members of the Department. In 1910 there were only two infected localities known between Masulipatam and the infected area in Narasapur and Tanuku Taluqs adjacent to the main infected area in Godavari District, viz., Gudivada near the former area and Kaikalur near the latter. Hence I was inclined to think that the disease had been carried to Masulipatam by sea by human agency, (as printed) which of course was quite possible. Subsequent information got by the Special Deputy Collector and Tahsildar, by one of my assistants and myself in extensive tours have led me to think that this explanation is unnecessary and that the disease could have travelled overland from the Godavari area. Granted that Kistna was infected earlier than was at first thought, and this seems very likely, the overland extension is quite feasible and in comformity with the facts of the then better known extension northwards in Godavari. The boundaries of the infected area about the end of 1912 enclosed a total area of about 4,000 square miles and with the exception of two small extensions along the coast at the extreme ends, comprise the limits of the infected area. Beyond the railway line from Rajamundry to Samalkota and Cocanada the land is not irrigated but is upland dry land of a slightly undulating nature. Here the extension has been slow and the disease has generally occurred in the shallow depressions. From quite early in the operations efforts have been made to banish it from this tract and with success. It is now confined to two small tracts near the railway line and one further up the coast. In one of the former round Rajamundry the disease is of long standing and is still intense. This has come about because the tree-owners there have all along been difficult to persuade to do anything or allow anything to be done, but the stimulus of the Pest Act will no doubt have the desired effect. The tract Peddapur consists of two very small areas where very few diseased trees are found now. The tract along the coast in Tuni Division comprised parts of two villages in 1914 but later was found to extend to eight. It was outside the area patrolled and had the diseases for some time before it was discovered, but work is being concentrated on it now. Beyond the railway line from Rajamundry to Bezwada the disease, so far as is known, has not appeared except in a few villages on the right banks of the Godavari river once believed to be free but now known to be still infected. It has actually reached Bezwada and Ellore halfway between the two as an extension from the delta. The Kistna river is the boundary on the west side except for two small areas near Repalle and Tenali which were discovered in 1920 beyond the patrolled area. They are now being dealt with thoroughly.

(c) *Intensity of the disease.*—The Kistna area was never so intensely infected as the Godavari one, with the exception of those parts of Tanuku and Narasapur Taluqs between the Narasapur canal and the Vasishta branch of the river, and has been more amenable to treatment by the operations. The

disease is in several isolated areas and is nowhere severe except perhaps comparatively so in the river-side villages. Though not to the same extent as in Kistna the disease has disappeared throughout the Godavari District from many places where it once existed and there are still five areas in which it is severe though nothing like to the same extent as formerly, viz., around Rajamundry, Mundapeta, Karapa, Vemavaram and Kottapeta. In general the disease has been pushed out and kept out of the uplands around the deltas except to a short distance on the banks of the Godavari river and in two other small areas, while in the deltas it has been thinned out especially towards the Kistna side and reduced in intensity.

(d) *The Cost.*—The total expenditure in connection with the operations from 1906 to 1921 has been in round figures three lakhs of rupees or £ 20,000.

Results of the Operations.

As in every fight against a disease it is well nigh impossible to make a complete estimate in figures of the good that has accrued, for besides the definite arithmetical value that can be put on the individuals that have been cured, there remains the value of those that have escaped taking the infection because of the protection given them through the preventive measures, and any estimate of this value is more or less speculative. The capital cost of a palmyra in the deltas is about two rupees on the average. The benefits of the operations may be stated under four heads. (a) The value of the palms that have been cured, taking the number at a conservative estimate at 90 per cent. of 231,631 " inwardly " and " outwardly " infected palms operated on, is 417,000 rupees. (b) in 1907 and 1908 the number of dead palms cut includes the accumulation of several years, but in 1909 the bulk of the old standing cases had been removed and the operations would have had some little effect in reducing the yearly number of dead palms, so 100,000 may be taken as representing the maximum intensity of the disease in 1908. Now if the disease had continued steadily at that intensity then in the 15 years of the operations 1,500,000 palms would have died. But during that time 758,000 died, so it can be said with confidence that 742,000 have been saved from infection and these represent a value of 1,484,000 rupees. (c) Again from the number of dead palms that were cut in 1907 and 1908 (398,000) it is clear that the intensity of the disease had been increasing rapidly since 1890 when it was first noticed and there was no reason against its going on as rapidly to increase in the next 13 years. Besides, from an analysis of the figures from June 1907 when the operations began to the end of 1908, together with the knowledge that an interval of three and half years may elapse between the death of the growing point and the withering of all the leaves of the crown, and that the disease arose in epidemic dimensions from a definite place in the Godavari delta about the year 1890 we can assume a simple progression in the rate of increase, then the figures for

	1908 would be	100,000
	1907	94,000
	1906	88,000
	1905	82,000
and for half of	1904	38,000
		402,000

the total of which is very near the figure for those actually cut, viz., 398,000. At the same rate of progression for the next 13 years the figures for dead trees would be about 1,790,000 multiplied by some factor comparable to 100,000, the number of dead trees in the beginning of the period of 13 years under consideration. Of course, the actual number is purely speculative, but it does show the nature of the proportions to which the disease was approaching. The prevention of the disease in this case has a potential value that cannot be accurately estimated in money. (d) In conclusion, we can affirm definitely that the disease has been reduced from a grave menace (100,000 in 1908) to a controllable factor (8,700 in 1921).

Though the disease has been greatly reduced it is still dangerous and requires to be treated with caution. So many times has it been found, more especially in the earlier years, that when a village was put out of the sphere of operation after it had shown no diseased trees for one year, and sometimes two in later years, after an interval of two or three years the disease appeared again, sometimes because of re-infection from outside but undoubtedly also from the appearance of a small number of cases in which the fungus had been developing slowly, consequently the disease had appeared after a longer period than usual and had again started a nucleus of infection that spread the disease to surrounding trees requiring the village to be brought under the operations once more. Hence the operations under the Pest Act will have to be continued for some years longer (1) to reduce still further the amount of disease and (2) to deal thoroughly and expeditiously with the three or four small outbreaks that have occurred beyond the hitherto patrolled infected area.

It was the influence the Collectors of the two districts and their subordinate officers had with the people that made it possible for these irksome operations to be carried on, the members of the special staff being recruited wholly from the revenue branch of the district administration. For years there was no legal compulsion behind the staff and the only authoritative backing it had till 1919 was the order of the Collectors to the village officers to attend to this work. (Naturally it was Government in the first instance that decreed the operations, provided the funds for the special staff, and decided on the continuance of the work. But I am referring just now only to the actual working of the operations in the districts.) The revenue inspectors could not legally compel anyone to cut diseased trees, nor had they the right to enter on anyone's land and cut diseased trees. Everything had to be done with the acquiescence and the co-operation of the people, and naturally it took a considerable time to get them to agree at first to allow the work of cutting to be carried on at Government expense and then gradually at their own expense, especially as for some years there was no very apparent good result and as they believed the disease to be the scourge of a malign deity which there was little use trying to escape. It reflects credit on the members of the staff that they did so much for so long without any person's taking proceedings against them, and again that the people have been induced to carry on the work during the last two years under the Pest Act with only one prosecution. That the credit for carrying on the operations against this disease with the measure of success achieved is due to the special staff under the direction of the Collectors of the two districts is freely acknowledged. The Agricultural Department's activities consisted in elucidating the life-history of the fungus, devising and improving methods of combating the disease, and giving encouragement.

During 1917, 1918 and 1919 the general examination went on during the dry months and the number of diseased palms decreased except in 1918 when it suddenly increased. This was a bitter disappointment. Even though there had been a series of unusually wet years we hoped that the operations now had a greater influence on the disease than natural conditions. In Kistna District the disease appeared again in thirty-seven villages that had been given over to the supervision of the ordinary revenue staff in 1912 and in twenty-one other villages in Bhimavaram, Kaikalur and Gudivada, and a few stray cases were cut at Bezwada, Ellore and Masulipatam, while in Godavari District a few cases were cut in Pelavaram. This shows the insidious character of the disease and how difficult it is to eradicate entirely from a village. From March 1918, when the number of infected trees were greatest, a special effort was made to get the disease again under control, and the general examination in 1919, when the staff tried to find every diseased tree, showed that the number had fallen again to previous proportions. In December 1919 and January 1920 my assistant Mr. Sundararaman and I toured by separate routes through the worst infected villages of both districts. Altogether we saw under thirty dead or outwardly infected palmyras even though operations had been suspended for the previous two months. In former years during December and January there had always been a large number of diseased palms and we expected to see several hundred. That so small a number of diseased trees was found on this tour of inspection was very encouraging and was an undoubted proof of the success of the operations.

From November 1919 to March 1920 the operations were suspended at the instance of the Director of Agriculture in order that the staff might carry on a campaign of publicity before the application of the Pest Act to the disease. It was in connection with the attempt to have outwardly infected trees dealt with that we first suggested early in 1912 to take legislative power to cut compulsorily such trees, but the Government declined to resort to compulsion till the need for it was much more clearly established. The operations went on accordingly relying on the tact and persuasiveness of the members of the special staff to overcome the difficulties. That they were successful in great measure has been shown in the discussion of the position of the operations from year to year, but they never induced any great body of the tree-owners to do the work spontaneously though they did persuade them to allow the cutting to be done at their (the tree-owner's) expense. By 1919 a definite proposal for a local Pest Act was accepted by the Government of Madras, and at a special meeting at Pusa, where the subject was discussed, the last objection to such an act was withdrawn and the way was finally opened for having it passed. Throughout the whole period of the operations there was one hope that never was realized to any great extent—the hope of interesting the tree-owners in the measure taken to combat the disease to such an extent as to get them to act for themselves. Had this hope been realized the special staff might have been withdrawn gradually and the people left to protect themselves against the loss from the disease. Most people in the infected area know about the disease and its symptoms but entirely depended on the official staff to deal with it. The next step was to stir up this interest. By the application of the Pest Act of 1919, dealing with

diseased palmyras became a duty, and it seemed not unreasonable to believe that after people got accustomed to tackling the disease themselves they would come to realize that they could fight it without extraneous help. To ensure that every person in the infected area and around it did know sufficient about the methods of dealing with diseased trees, his duties under the Act and the penalties for non-compliance, the special staff stopped the operation and devoted themselves to a publicity campaign. The fact of the operations being entirely stopped for four months seemed to have impressed the people that Government was in earnest. Pamphlets in the vernacular were written with illustrations given in colour and distributed to all the literate people directly and indirectly connected with the villages and small posters with an illustration of a diseased palmyra palm were posted in thousands on conspicuous places. To reach the great bulk of the tree-owners, who were illiterate, meetings were held in the villages where " sandwichmen " were sent round by day and lantern demonstrations were given by night. Verses were written and folksongs adapted and they were sung at festivals and fairs and mask dances were also a feature. Everything possible was done to excite interest and there is no doubt of the success of the campaign, and the credit is in great measure due to the energy and fertile brain of M. R. Ry. Rao Sahib, V. Bhogappayya Sastry Garu, B.A., Special Deputy Collector on Palm Duty in Godavari and Kistna Districts.

In 1924 when the complete operations were being carried on with the additional stimulus of the Pest Act, the number of diseased trees found remained low, being 16,500 in 1920 and 8,700 in 1921.

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THE COCONUT PEST IN SOUTH CANARA.

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HOW CONTROLLED.

The black-headed caterpillar, called by Entomologists *Nephantis serinopa*, appeared in Mangalore about 4 years ago, and commenced destroying the green tissues of the coconut leaves. Within a short time as many as 30,000 trees were attacked and more would have shared the same fate but for the timely intervention of the Government Agricultural and Entomological Departments. In order to tackle the situation better the Pest Act was introduced in 1923, and the task of checking the fast-spreading disease was transferred to the Revenue Authorities who, in their turn, deputed a first grade Revenue Inspector to be in sole charge of the control operations, but as a close technical knowledge of palm diseases was necessary for conducting them efficiently, the Government Entomologist continued to take the same keen interest as he did when the pest first broke out.

Briefly, two methods were employed for combating the pest, which had by now firmly established itself, and the first to be adopted was a sort of a preliminary or tentative measure. In its results, however, it at times proved worse than the malady, for it often killed the trees to which it was applied, but it did arrest the pest. The affected fronds were cut and burnt in order to prevent the moths on them from flying back and reinfesting the trees. In spite of bitter criticism and occasional open opposition this method was systematically applied until a scientific remedy was invented.

The second method resorted to consisted in the employment of certain insects known as parasites to arrest the progress of the pest. These acted as an internal enemy or as a new pest to destroy the old. Here it is necessary to inform the readers that the *Nephantis serinopa* passes through four stages, viz., the egg, the caterpillar or larvae, the pupal or chrysalis and the adult. It is in the second stage that the pest is most harmful to the trees. Very early in his investigation the Entomologist came across a parasite which was breeding within the chrysalis of the pest, and the only object of the pest staff was to multiply this parasite, it being a discovery of inestimable economic value. If the chrysalis was parasitised, no moth would emerge from it and the pest itself would in due course die out. This was the line of action taken by the Entomologist. In other words, the parasite found was to be multiplied, and for this purpose a cage was constructed. It was a simple contrivance consisting of wooden framework covered with iron gauze. These cages were placed in pest-infected topes, and the branches cut from the affected trees were put into them. While the parasites escaped out of the wire gauze, its close meshes would not permit the pest moths to follow them. These moths were destroyed and the parasites liberated flew to feed upon new chrysalis. This operation, though slow and tedious, was repeated until the parasite was spread over the whole infected area to carry on its work of destruction. Left to itself the parasite would not multply as fast as it did by artificial means.

The Pest Officers did not rest here. They imported from the east coast parasites which fed on both the caterpillar and the chrysalis, so that the pest was attacked from two points instead of one. The newer parasites were obtained from the Madura, N. & S. Arcot and Chingleput Districts among other places. As consignments of these insects were received, they were conveyed to where the pest prevailed and released. It was a novel enterprise. The imported parasites spread with the necessary speed and controlled the original pest as anticipated by the control staff. Of the four new parasites obtained from outstations, the *Bethylid*, *Braconid* and Elasmid, the representatives of three different species, preyed on the caterpillars, while the fourth, the Eulophid, assailed the chrysalis along with the local enemy described elsewhere.

SOILS AND MANURES.

CAUSES OF INFERTILITY IN SOILS IN RELATION TO BACTERIAL ACTION.*

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Infertility as a negative term suggests the absence of elements required for fertility; it is necessary, however, to realize that infertility may result from the presence of substances or conditions inimical to the growth of plants.

The causes of infertility in soils may, therefore, be divided into two main groups or classes:—

(1) Those associated with the absence of substances or conditions necessary for fertility.

(2) Those depending for their action upon the presence of deleterious substances or conditions liable to interfere with the growth of plants.

To the layman an infertile soil suggests either a desert tract entirely bare of vegetation, or perhaps an area at one time under cultivation but now abandoned because of its infertility. The agriculturist, however, has a much higher standard of fertility in mind; to him an infertile soil is one which it does not pay to cultivate or at the best is of such poor quality or condition that nothing but necessity would make him spend his time and labour in doing so. To this latter class belongs a large proportion of the arable lands now under cultivation; these have come down from their original condition of high fertility as virgin soils to their present state of comparative infertility as a direct result of the artificial conditions of plant growth to which they have been subjected during years of crop cultivation. It is with this class of soils requiring highly expert treatment and knowledge that we are mainly concerned, those in which the degree of fertility is so low that relatively small causes, or infertility factors may at any moment reduce their yield below the point at which it ceases to pay to cultivate them. It is therefore of prime importance for the agriculturist to be well acquainted with the various and numerous causes of infertility which may reduce the condition of his soil and the amount of his crop below the paying minimum.

One of the most common and well understood causes of infertility is the lack of a sufficient supply of those ingredients in the soil which are necessary for fertility. It is impracticable here to deal with these except to point out that an insufficiency of plant foods not only affects the growth of crops directly but also indirectly by limiting the activities of those bacteria upon which fertility depends. This is more especially the case with reference to the supply of humus, for reasons to be dealt with later.

* Lecture delivered to the Pusa Scientific Association on 22nd December, 1925.

Water supply of course is a vital factor and must be taken account of both from the point of view of deficiency and of excess; this implies management of the soil in such a way as to avoid both deficiency or excess of water, the latter with its concomitant result of lack of air being especially conducive to infertility by reason of its effect on bacterial activities in the soil.

On the other hand, infertility may result from the presence of harmful substances in the soil such as excess of organic acids or of alkali salts and in some cases of neutral salts including chlorides, sulphates and nitrates. With these causes of infertility we are not for the moment concerned, but others more generally distributed exist which are of great importance although perhaps not fully recognized as such. Under certain conditions toxic bodies are produced in soils and their influence upon fertility depends largely upon the quantities in which they are present. Generally speaking, their production depends upon the existence of anaerobic conditions due to waterlogging and is the result of bacterial action of the class associated with this condition. In order to understand not only how such bacterial action takes place but to arrive at an adequate conception of its importance as a factor in soil infertility, it is necessary to know something about that class of soil organisms known as anaerobic bacteria. There is no definite dividing line between aerobes and anaerobes, that is between such bacteria as require oxygen and those that do not; there is an intermediate class the members of which can tolerate varying degrees of aeration or the reverse and even those species which are apparently obligate anaerobes can function in presence of small amounts of oxygen, especially in conjunction with certain aerobic species whose activities reduce the oxygen tension in the soil water. The fact that it is necessary to bear in mind is that soil conditions, so far as anaerobism or the reverse is concerned, determine whether anaerobic or aerobic bacteria shall predominate in such soils with results which will vary in accordance with the characteristic differences of their action.

Anaerobic bacteria and anaerobic fermentations are generally associated with unhealthy conditions of one kind or another; thus putrefaction as opposed to decay is produced mainly by anaerobes, which are also responsible for most septic conditions and incidentally for tetanus.

Anaerobic bacteria in soils produce infertility in several ways:—

(1) By the production of colloidal bodies resulting from decomposition of organic matter, plant residues, roots and stubble, dead leaves, green manures, oilcakes and cattle manure. These colloidal bodies take the form of bacterial waxes or slimes which coat the surfaces of the soil particles and tend to block up the pores of the soil, thus interfering with aeration and drainage. It is of interest to note that the coating of the soil particles both organic and inorganic with bacterial wax has the effect of protecting them from further bacterial action, thus reducing the rate and amount of such important processes as nitrification or organic matter and solubilization of mineral phosphates. The fertilizing action of such partial sterilizing agents as toluene can be partly attributed to their solvent action upon this coating, exposing fresh surfaces to bacterial action; a similar result is produced by the mechanical rubbing and grinding action of cultivation processes such as ploughing and harrowing, and also by the aeration and desiccation resulting from the latter which tends to destroy the colloidal condition of the bacterial

slimes. It is important to realize that anaerobism in soils tends to increase by reason of the fact that the anaerobic classes of bacteria, whose growth and preponderance results from the prevalence of this condition, are themselves capable of contributing to and increasing it by the production of colloids; thus the vicious circle is completed and this tendency becomes of great practical importance.

(2) by the production of toxic bodies which reduce fertility either (*a*) directly as plant poisons, or (*b*) indirectly by their interference with nitrification.

The first case involves exceptional conditions such as waterlogging, or a soil of naturally high non-porosity such as a heavy clay.

Waterlogging in the presence of organic matter results in the production not only of colloids but of plant poisons by anaerobic bacteria. The presence and action of such poisons can be demonstrated by watering plants with extracts of anaerobically incubated soils, apart from the well known effects of attempting to grow plants in soils in which drainage has been interfered with or in which anaerobic fermentation of organic matter has been carried out to excess.

The maize plant affords an interesting case of natural provision against poisoning by organic toxins resulting from soil anaerobism; the secondary aerial root system commonly found in this plant is a provision against the absorption of toxins resulting from anaerobic conditions due to excess of moisture in the subsoil, which the plant is able to avoid by putting out secondary roots into the surface soil at that period of its growth when flooding of the soil is liable to occur.

Intoxication of the seedling maize plant is also liable to occur in wet soils as a consequence of bacterial invasion of the seed whilst the latter is still attached to and is providing nutriment to the young plant. This form of damage is probably due to mechanical injury to the seed-coat generally as a result of insect attack.

A special case of anaerobism is that produced by the growth of grasses, the closely interwoven roots and stoloniferous stems forming a sod or layer not only relatively impervious but giving rise to extra quantities of CO_2 in the surface soil by their decay. There is reason to believe that under certain conditions especially in wet seasons, toxins are formed as a result of the decay of parts of this growth; this result may be noticed where cut grass from the mower is allowed to lie during wet weather on the surface of turf, which is completely killed by this treatment and may not recover for months afterwards. In addition, the partially anaerobic conditions induced in the soil interfere with nitrification and consequently reduce fertility; this effect may be observed and measured and is probably responsible for the very marked and well known inhibitory action of grass upon the growth of trees.

Indirect action of toxins on fertility.

Nitrifying bacteria are known to be highly susceptible to the action of toxins of various kinds. Soil sterilized by heat is not only lacking in nitrifying organisms but when these are reintroduced by inoculation their normal action is inhibited by toxic bodies produced by the action of heat upon the

organic matter present. Similarly anaerobic incubation of soil results in the production of toxins having an inhibitory effect upon nitrification, and in addition cases have been observed where anaerobic conditions in a soil have resulted in the multiplication of specific bacteria, capable of inhibiting nitrification by the toxic action upon the nitrifiers of the bye-products of their metabolism. This action is most pronounced in presence of organic matter, which will fail to nitrify in a soil under reduced air supply, whereas the same soil under similar conditions of aeration will nitrify ammonium sulphate. That this inhibition of nitrification is due to the production of toxins from the organic matter is shown by the fact that nitrification does not immediately take place in a soil treated in this manner when complete aeration is provided subsequently, but only commences after a period of time (some ten to fourteen days) sufficient to allow of destruction by oxidation of the toxins thus formed.

In this case therefore we have an instance of infertility caused by interference with nitrification and resulting from the action of toxins not present in sufficient amount to produce directly harmful action on plants. The importance of recognizing this source of infertility lies in the frequency of the occurrence of the conditions giving rise to it. Any condition of the soil causing any degree of anaerobism will encourage the growth of those classes of bacteria responsible for the effects described above; such conditions may arise from improper soil management, such as ploughing when too wet, or from physical properties of the soil itself rendering it peculiarly liable to this source of infertility.

Relation of the above facts to Agricultural Operations.

Agricultural operations consist mainly of:—

(1) Cultivation, *i.e.*, stirring the soil.

(2) Irrigation or drainage, *i.e.*, controlling the water supply and with it the air content.

(3) Manuring—the addition of plant food in a suitable form.

(4) Selection of suitable crops and of improved varieties to make the most of natural fertility or to minimize the effects of natural infertility.

Cultivation.—The principal function of cultivation is to regulate the water supply of the soil and promote formation of available, *i.e.*, soluble plant food, especially nitrates. Nitrification depends upon a suitable balance between air and water supply and upon removal or oxidation of certain bye-products of bacterial metabolism; if this is not provided for, either nitrification does not proceed at a sufficient rate or the reverse action, *i.e.*, reduction of nitrates by bacterial action occurs, the bacterial balance being then against the accumulation of nitrates sufficient for fertility. Therefore the operations of ploughing, harrowing, rolling and inter-cultivation must be carried out with a view to maintaining in the soil such conditions of water supply and aeration as will promote nitrification at that time of year when the growing crop is ready to absorb it. Hot weather cultivation has other functions besides that of killing out weeds; this operation has a very decided action in lowering the percentage of anaerobic bacteria, destroying many of the deleterious bye-products of their growth, including some colloids, by oxidation and desiccation, and probably strongly discouraging certain infective and

pathogenic organisms such as *Ps tritici* and *Bact. solanacearum*. Ploughing wet has an extremely bad effect on many soils; the result is infertility due mainly to destruction of the mechanical condition or tilth, this is brought about largely by the operation of a most important factor in soil physics, namely the film of air which coats and closely clings to the soil particles and is only displaced with difficulty; this air film plays an important part not only in the biological activities of the soil, but in maintaining its physical condition, and exercises a vital influence in preventing waterlogging of the soil particles. Ploughing the soil when it is dry, by breaking up the particles, increases the area of their surfaces and with it the content of the air held in the form of the air film upon these surfaces. Ploughing when wet, however, abrades the air film and rubs it off, replacing it with water, removing the permanent air supply and bringing the soil particles into close and adhesive contact. The puddling of clay such as is effected in a pug mill depends upon the action.

Apart from the deleterious influence of compaction upon the biological processes of soil, especially nitrification, it must be remembered that plant roots have to penetrate soil by sheer mechanical pressure and that many crops fail to do this in soils or subsoils whose texture is so close as to present mechanical resistance too great for easy penetration; the " pan " liable to occur in arable soils at the lower limit of cultivation is a familiar instance of this condition.

Drainage.—The principal object of drainage is to prevent the formation or persistence of anaerobic conditions in the soil; it is unnecessary to repeat the reasons for considering anaerobism fatal to fertility, but it may be pointed out that in a soil of average texture and fertility not only may the whole existing supply of nitrates be destroyed in a few days' time by the existence during that period of anaerobism due to waterlogging, but conditions may be set up which will seriously interfere with the process of nitrification after removal of the excess of water.

Irrigation.—Where irrigation is the standard method of water supply for the crops, knowledge of the infertility factors above described is of even greater importance than in unirrigated areas. Control of the water content of the soil not only places in the hands of the cultivator the power of supplying the water requirements of his crop, but makes it essential that he should possess all the information available as to the relation between soil moisture and the numerous and complicated biological processes making for fertility or the reverse, and dependent on appropriate or mistaken use of this control. As the writer pointed out in a paper in the *Agricultural Journal of India*, * there is great need for research and investigation into the water requirements of soils under irrigation; such enquiries could only be effectively carried out in irrigation areas and must give due weight to the biological factor. It is probable that the highly important problem of natural fixation of nitrogen in Indian soils is more likely to be solved by study of irrigated than unirrigated soils, and the results of the application of the solution will most probably be more readily attained in the former.

* Agri: Jour. India, XX, 4, p. 270.

Manuring.—The practice of manuring is a recognition of the depletion of soil fertility by the artificial cultivation of crops. It is of course impossible here to deal with this large subject in any way except to mention one or two points in connection with the relationship between the use of manures and the action of soil bacteria. We may consider as examples the supply of available nitrogen and phosphates as of practical interest and importance.

Nitrogen.—Reference has already been made to the conditions, both favourable and the reverse, which occur in soil and which influence the conversion of unavailable organic nitrogenous food into nitrates. It has been pointed out that suitable conditions so far as air and water supply in the soil are concerned must be provided by appropriate cultivation; it is also necessary to know something about the capacity of particular soils to deal with the sources of nitrogen in question, *i.e.*, whether the soil of an area under manurial treatment is capable of nitrifying the material available for this purpose. This introduces the interesting fact that instances have been found of soils in which not only does nitrification not occur, but examination has shown that nitrifying organisms are absent altogether. Although such soils are in most cases of a low grade of fertility and will carry only certain crops, in other instances such as some tea soils, the crop flourishes and responds to ordinary manurial applications in such a way as to suggest that nitrate nitrogen is not necessary to its growth or well-being. This of course is also the case with rice under swamp conditions, to which crop nitrates are apparently not only unnecessary but actually harmful, except in the seedling and in the latest stages of growth. In certain soils from the neighbourhood of Ranchi containing no nitrifiers I have found it possible to induce nitrification by artificial inoculation with nitrifying bacteria, but this improvement would probably not be a permanent one unless intensive cultivation and applications of lime were maintained over considerable periods.

Another consideration arises in connection with the nitrification of organic manures, this being the suitability of the latter for the process. Observation of the nitrification rate of various nitrogenous materials shows a wide variation in their suitability as evidenced by this rate; *mahua* cake for example only nitrifies in soil after prolonged periods of time, probably owing to its content of saponin. In practice, it is important not only to keep this in mind, but to be aware of the fact that nitrification is inhibited both by unsuitable soil conditions and by the application of excessive amounts of organic nitrogenous material. Other important factors come into operation in this connection and must be taken into account, but time forbids reference to them except to mention the possibility of loss of nitrogen as nitrate under conditions where the nitrification rate is so high as to lead to removal of nitrate by leaching by rain water passing through the soil. For this reason it is frequently advisable to apply dressings of cake in separate doses during the growing season of the crop, in place of all at one time.

Phosphates.—The availability of phosphatic manures is intimately connected with bacterial action in the soils to which they are applied. Two distinct styles of bacterial activity are concerned: (1) those which tend to solubilize otherwise insoluble phosphates; (2) those whose action results in diversion of phosphate from the supply originally available for the plant.

(1) It is probable that a large proportion of the naturally available, because soluble, phosphate in the soil is in this condition as a result of acid reactions set up by bacterial activity, either by formation of organic acids or of carbon dioxide. It was originally considered that this action, generally associated with the decomposition of plant residues, such as green manures, oilcakes and cattle manure, resulted in the direct supply of soluble phosphates to the crop, and might be intensified by the method of composting mineral phosphates with organic matter. Experience, however, has yielded disappointing results with this method when utilized with the intention of obtaining supplies of soluble phosphates, and it has consequently been largely abandoned; this in my opinion is a mistake, as the apparent failure of the method is due to the appraisement of the results in terms of directly soluble phosphate as is the practice with superphosphate, whereas so far as work at Pusa on this subject has gone it appears that changes in the condition of the original insoluble phosphate due to bacterial fermentation in the compost, take place leaving a certain proportion in a relatively available condition in the form of organic phosphorus compounds, probably constituents of the bacterial cells themselves. Evidence exists leading to the conclusion that the P_2O_5 held in this combination can serve as plant food under soil conditions, either directly owing to the death of the bacterial cells or to later changes in the soil of an indeterminate nature. My present opinion based on field and laboratory experiments is, that bacterial action under suitable conditions is able to convert phosphate into organic combination and remove it from those influences which would otherwise tend to produce chemical reversion to the insoluble tricalcic condition; this organic combination will later present a source of phosphate food of relatively higher availability than the tricalcic form resulting from purely chemical reversion, or existing as such originally. The practical agricultural method of securing this result depends merely upon the provision of adequate soil moisture and sufficient organic matter to promote vigorous bacterial growth and activity; this is one of the principal functions of such operations as green-manuring.

A more specialized style of solubilization of phosphates occurs in the case of that effected by sulphur oxidizing bacteria. Time does not permit of anything more than reference to this process which I described in an article in the " Agricultural Journal of India " (January, 1924) and at the last meeting of the Board of Agriculture at Bangalore. It is of course an artificial method depending on the use of sulphur and bacterial cultures capable of producing sulphuric acid therefrom, but it is of interest to note that the method is now being tried on a commercial scale as a source of phosphatic manure.

(2) With reference to that class of bacterial action resulting in removal of phosphate from the root range of the growing crop it must always be remembered that bacteria are plants and as such will compete with the agriculturist's crop for plant food in the soil. We have seen that this happens in

the case of nitrates and there is reason to believe that it is an equally important phenomenon as applied to the supply of phosphates; thus superphosphate when applied to a soil is partly taken up by the crop, partly reverted by chemical action, and partly absorbed by bacteria. As we have seen above, there is reason for supposing that this last portion remains relatively available as compared with that which has undergone chemical reversion, so that there is no reason for treating this form of bacterial activity as one likely to produce infertility in the soil.

On the other hand practical experience shows that in our Pusa soils the combination of green manures with superphosphate produces the best results, so that on the whole we may consider bacterial action in the soil as a favourable influence so far as supplies of available phosphate are concerned, and the aim of the agriculturist should therefore be to encourage such activity as much as possible. This can be done mainly by maintaining adequate supplies of organic matter, and the inclusion of the usual methods of doing so in agricultural practice forms another instance of a correct method based on empiricism derived from experience.

The selection of crops and use of improved varieties is too large a subject to be dealt with here. One point may be referred to and that is the selection of varieties with special reference to the depth of root range of the plant; here we come in direct contact with soil conditions involving degrees of anaerobism or the reverse, varying in accordance with the character of the soil and its agricultural treatment. Knowledge of the unfavourable effects of anaerobism such as have been described above will not only serve as an additional incentive to the use of such agricultural operations as will tend to diminish this condition, but may lead to the use of shallower rooted varieties in situations where soil and climate may render this additional precaution necessary.

In conclusion, it may be emphasized that so far as soil fertility is concerned, this condition or its opposite can never be ascribed to one simple cause alone but is associated with the interaction of several. It is incorrect to say, for example, that lack of oxygen causes infertility only because plant roots require oxygen for healthy growth; we have seen that conditions in the soil producing an insufficiency of air tend to cause infertility through the combined operation of a number of factors, some positive such as the production of toxins and of colloids by anaerobic bacteria, and others negative such as the failure to form nitrates for want of sufficient oxygen to maintain the proper bacterial balance in the soil. The complete investigation of the reactions and especially the bacterial activities underlying and ultimately responsible for the complex changes and conditions in a soil, is essential and necessary for any understanding of the problem of soil fertility; in this country especially, owing to the high soil temperatures which prevail during a large part of the year, and the correspondingly rapid bacterial changes resulting therefrom, any advance towards solution of this problem must depend upon adequate recognition of the intimate connection between soil fertility and soil bacteriology.—Agricultural Journal of India, Vol. XXI, Part 2.

CEYLON AGRICULTURE.

ESTATES PRODUCTS COMMITTEE.

Minutes of the twenty-eighth meeting of the Estates Products Committee of the Board of Agriculture held at the Head Office of the Department of Agriculture at 2-30 p.m. on Thursday, May 13th, 1926.

Present.—The Director of Agriculture (Chairman), the Government Mycologist, the Government Entomologist, the Government Agricultural Chemist, the Acting Divisional Agricultural Officer, Central Division, Dr. W. P. Rodrigo, Messrs. J. Horsfall, A. H. Reid, G. W. Hunter-Blair, Geo. Brown, R. G. Coombe, H. D. Garrick, N. G. Campbell, J.S. Patterson, J. D. Dunlop, D. Whitelaw, R. P. Gorton, C. C. Du Pré Moore, C. G. Spiller, E. C. Villiers, C. E. A. Dias and T. H. Holland (Secretary).

Visitors.—Dr. N. A. Brittan, Messrs. W. A. Fitzpatrick, A. Coombe, H. Wilkinson, S. W. Mackintosh-Smith, H. W. Kennedy, G. W. Newton, and Dr. C. H. Gadd.

Letters or telegrams regretting inability to attend were received from the Hon. the Controller of Revenue, Messrs. H. W. Roy-Bertrand, C. B. Loudoun Shand, A. T. Sydney Smith, E. Maberley Byrde, H. Scott, J. E. P. Rajapakse, L. A. Wright, H. L. De Mel, and J. B. Coles.

The minutes of the last meeting which had been circulated to members were taken as read and confirmed.

Agenda Item 1—Progress Report of the Experiment Station, Peradeniya, for the months of January, February, March, and April, 1926.

The Chairman briefly reviewed this report. Mr. J. Horsfall in referring to figures of soil moisture under cover crops asked whether any top shade was present.

The Chairman replied that there was only the young rubber among which the cover crops were growing.

Mr. Horsfall also enquired whether the ground had been forked before planting the *Indigofera endecaphylla* in tea.

Mr. Holland replied that the Indigofera had been planted in forked land immediately after applying a pruning mixture.

Mr. Horsfall said that it was his experience that *Indigofera endecaphylla* was greatly improved by forking through it.

Mr. R. G. Coombe enquired why the Gliricidia trees in the Half-acre tea plots were only lopped three times in 1923 and in 1924 and enquired whether shortage of labour was the cause.

Mr. Holland said that he did not think shortage of labour was responsible.

Agenda Item 2—Stream Reservations and Soil Erosion.

A copy of the Colonial Secretary's circular to Government Agents on this subject had been circulated to members.

The Chairman said that this circular was the outcome of some of the recommendations made by the Committee to Government from the report of the Sub-Committee which had been appointed to study the question of soil erosion.

Agenda Item 3—Report on Rubber Tapping Experiments, Peradeniya, 1925.

Mr. Holland reviewed the report.

Mr. Reid asked that particulars of rainfall should be published with the results of experiments. The question of whether rain fell during tapping was of importance.

Mr. Dunlop said that most rubber estates kept separate records of the morning and afternoon rainfall.

The Chairman said that Mr. Taylor of the Rubber Research Scheme was studying the correlation between rainfall and rubber yields.

Agenda Item 4—Report on Rubber Manurial Experiments, Peradeniya, 1925.

Mr. Holland reviewed this report.

Agenda Item 5—Rubber budding—The present position.

A brief report was tabled giving yields from budded rubber in comparison with seedlings in Malaya, Java and Sumatra.

Mr. C. E. A. Dias, who introduced this subject, exhibited some interesting photographs of budded trees on his estates showing the difference between the growth of trees budded in the field and in the nursery. He had come to the conclusion that budding in the field on one-year-old plants was the best method. He had also successfully put buds on to stumps on comparatively old trees. He enquired whether the Department had any information about a report which had been received from Sumatra that a yield of 1,760 lb. of rubber per acre had been obtained from budded rubber. He urged the desirability of distributing bud-wood from No. 2 Tree Henaratgoda for budding purposes in different districts.

He enquired if information as to the acreage of budded rubber in Ceylon was available.

The Chairman referred to the statement tabled which showed in almost every case a considerable superiority of yield from budded rubber. Opinion was now changing and was considerably more in favour of budding. The report from Sumatra referred to had also been received by the Department but he had no information as to its accuracy or otherwise. He would be glad to do all that he could to foster the budding of rubber in Ceylon. A certain amount of bud-wood could be available from No. 2 Tree Henaratgoda this year and he agreed to make a supply of this available to estates desirous of securing bud-wood from that tree.

The acreage of budded rubber in Ceylon was not known but if the Committee thought it desirable the information could be obtained.

On the question being put to the meeting a motion was passed in favour of ascertaining the acreage under budded rubber in Ceylon.

Dr. Rodrigo enquired whether bud-wood would stand the journey between different districts.

The Chairman replied that there was no difficulty involved. Bud-wood had been sent from Sumatra and Java to Malaya.

Mr. Garrick enquired whether the large stumps mentioned as having been budded by Mr. Dias would not die.

Mr. Dias hoped that they would be entirely covered over by bark.

The Chairman was doubtful whether this would occur.

Mr. Campbell enquired how many buds Mr. Dias had put on these stumps.

Mr. Dias replied only one.

Dr. Rodrigo enquired if there was any danger to be anticipated in budding rubber.

The Chairman replied that as far as was known no increased susceptibility to disease or other danger was to be anticipated. He regarded the budding of old rubber however as quite experimental.

Agenda Item 6—Tea Tortrix.

The Chairman referred to the report on the survey of the Maskeliya district by the Entomologist and Assistant Entomologist.

Mr. A. H. Reid said that judging from the report the estate of which he was in charge was at present considerably more heavily infested than any estate in Maskeliya. He gave figures of the numbers of caterpillars collected.

Mr. Spiller said that Vellai-oya estate was formerly very badly infested; the estate was now well provided with high shade and tortrix was a negligible factor except where high shade was deficient.

Mr. R. G. Coombe confirmed the value of high shade.

Mr. Dunlop gave his experience of attacks of tortrix on rubber where no tea was to be found in the vicinity. The attacks were at long intervals and were of short duration. He believed that crows were responsible for destroying the tortrix.

Mr. Brown said he believed he had also seen crows feeding on tortrix.

Mr. Dunlop gave an instance of crows devouring the fringed nettle grub.

Mr. Reid supported the theory of the value of high shade and gave figures of caterpillars collected from areas with and without such shade.

Mr. Campbell said he had seen the line of flight of tortrix moths changed by the presence of high shade.

Mr. R. G. Coombe thought it inadvisable to await reports of fresh infestation from Maskeliya. Investigations might be conducted on other estates now known to be attacked. He believed that the Ceylon Estates Proprietary Association had sent a communication to the Director of Agriculture. He thought however that the Department should continue investigations wherever possible.

Agenda Item 7—Green and Brown Bug on tea.

The Chairman referred to the report by the Entomologist on his visit to the Haputale district. He expressed his thanks to the Chairman of the Haputale Planters' Association for arranging the meeting that had been held. He thought that the position in the Haputale district had been made clearer. It was probable that the pest would have to be tackled by Agricultural means rather than by strictly entomological methods.

With regard to the water reservation he had made representations to the proper authorities as to the measures necessary.

Mr. R. G. Coombe thanked the Chairman for the prompt response to his request for action in this matter.

Agenda Item 8—Report on Coconut Experiments on Alexandra Estate, Jaela.

This item was postponed owing to the absence of Mr. J. E. P. Rajapakse.

Agenda Item 9—Occurrence of the Coconut Caterpillar in the North-Western Province.

A report was presented from the Plant Pest Inspector, North-Western Division.

The Chairman said that either an individual estate or a headman's division could be proclaimed as infested. He sought the opinion of the Committee as to the best measures to be adopted at present in the North-Western Province.

Mr. Patterson was of the opinion that the attack was likely to pass off with the advent of rain. He advocated continued educational propaganda with regard to this pest and the visiting of badly infected areas by the Plant Pest Inspector but was not in favour of any drastic measures being enforced in the present instance.

Mr. Dias gave an instance of the unsuitability of headmen as agents for enforcing the Plant Pest Ordinance.

Dr. Hutson said that the cutting and burning of all affected branches was a measure that had been designed to combat a very severe attack in the Batticaloa district. In the North-Western Province where the attacks were not so severe and where the pest was largely controlled by climatic conditions and by parasites the same measures were not required.

The meeting agreed that the coconut caterpillar in the North-Western Province should be dealt with departmentally and that no legal action should be taken for the present.

Agenda Item 10—The Fermentation of Ceylon Cacao.

A report from Messrs. Cadbury Ltd., on the cacaos produced in the last series of the experiments carried out on the Experiment Station Peradeniya, was presented.

The Chairman summarised the conclusions of the report and proposed a vote of thanks to Mr. A. W. Knapp, Messrs. Cadbury's Chemist. This was carried.

Agenda Item 11—Roselle Fibre.

A further report from the Imperial Institute on Roselle fibre grown and prepared on the Experiment Station, Peradeniya, was presented.

Agenda Item 12—Pests and Diseases—Fumigatorium.

The Chairman said that it had been decided that a new Fumigatorium should be built. Plans had been drawn up by the Entomologist and he considered that in the interests of Agriculture the building should be erected in the coming financial year.

A resolution was passed that representations should be made to Government that the building of the new Fumigatorium should be proceeded with as early as possible.

The Chairman then referred to Dr. Brittan who was visiting the Island in the interests of a firm dealing in Calcium cyanamide. Dr. Brittan was demonstrating the use of Calcium cyanamide against termites. He was shortly going up to Haputale.

Mr. R. G. Coombe suggested that Dr. Brittan might return to Colombo *via* Ratnapura and visit an estate in that district where termites were a serious pest and were causing grave anxiety.

The Chairman replied that though Dr. Brittan had obtained considerable success against the mound building termites he was doubtful of success against the kind of termite found on the estate in question.

Oidium on Rubber.

Mr. E. C. Villiers asked if the oidium found on rubber was also found on other plants.

Dr. Small said that species of Oidium were common on a number of plants, but generally these species did not pass from one plant to another.

Dr. Gadd emphasised the difficulty of identifying the different kinds of oidium since identification was only possible in certain stages which did not always occur in Ceylon.

The Chairman said Mr. Stoughton-Harris had unsuccessfully tried to inoculate rubber trees with oidiums from other plants.

Dr. Small mentioned that he had had a similar experience in Uganda.

Tea Box Woods.

The Chairman referred to a specimen of the wood of *Agathis robusta*, the Queensland Kauri pine, which was exhibited.

The tree in question, which had been growing in the grounds of the King's Pavilion, was diseased and had been blown down. He suggested the possibility of the use of Kauri pine wood for tea chests.

Mr. Horsfall said that the trees certainly grew well and yield an immense amount of timber but seasoning of the wood—possibly by immersion in water—was absolutely necessary. The specimen exhibited was quite unseasoned.

Rubber flooring.

Mr. R. G. Coombe referred to the inconvenience felt in the Board Room by the noise caused by movement on the floor of the upper story. He proposed that the Rubber Growers' Association should be asked to present a rubber floor for the upper story.

This was passed.

T. H. HOLLAND,
Secretary,
Estates Products Committee,
Peradeniya.

TEA RESEARCH INSTITUTE.

SECOND MEETING OF BOARD.

Minutes of the second meeting of the Board of the Tea Research Institute of Ceylon held at the Victoria Commemoration Buildings, Kandy, on Saturday, the 13th March, 1926, at 12-30 p. m.

Present.—Mr. J. W. Oldfield (Chairman), Messrs. George Brown (Chairman, Planters' Association of Ceylon), G. C. Slater (Chairman, Ceylon Estates Proprietary Association), the Hon'ble Mr. F. A. Stockdale (Director of Agriculture), Messrs. D. S. Cameron, M. L. Wilkins, R. G. Coombe (Planters' Association of Ceylon), P. A. Keiller, J. D. Finch Noyes (Ceylon Estates Proprietary Association), Col. T. G. Jayawardene (Low-country Products Association), Mr. T. Petch (Director), Mr. A. W. L. Turner (Secretary) and Mr. John Horsfall (visitor).

Notice calling the meeting was read. Minutes of the first meeting held on the 7th January, 1926, were confirmed.

The Chairman, before commencing the business of the meeting, said that he wished on behalf of the Board to extend a warm welcome to their old friend and first Director, Mr. T. Petch.

Mr. Petch having thanked the meeting explained some of the difficulties experienced in collecting the staff.

Staff.—Votes having been recorded by the circulation of papers the following decisions of the Board were tabled and are incorporated in the minutes in accordance with section 10 (2) of Ordinance No. 12 of 1925:—

1. That the Board is in agreement with the Chairman that the appointment of Mycologist, Senior Chemist, and Botanist should not be made till Mr. Petch arrives in Ceylon.

2. That the Board is in favour of engaging Messrs. Evans and Light on the terms proposed by the London Committee.

Finance.—A letter from Mr. John Still was read, conveying the advice of the Attorney-General on the subjects of (1) the report for the year 1925, required by Ordinance No. 12 of 1925, (2) the repayment of expenses incurred on behalf of the Tea Research Board prior to the actual passing of Ordinance 12 of 1925, and (3) legal advisers to the Board.

Read letters from the Colonial Treasurer notifying the collection of the following sums on account of the Tea Research Institute during the periods stated:—

Tea Cess Rs 19,705·26 to end of December, 1925.

Tea Cess Rs. 17,123·01 to 26th January, 1926.

Tea Cess Rs. 16,861·49 from 27th January, 1926, to 27th February, 1926.

Total to date Rs. 53,689·76.

Referring to the statement of accounts, which was tabled and which appears at the end of the minutes, the Chairman remarked that Rs. 20,000 has been remitted to Government in part payment of the loan of Rs. 30,000 and that the balance of Rs. 10,000 would shortly be repaid.

The following resolutions were then put to the meeting and carried :—

1. " That Mr. T. Petch be engaged on a salary of £ 125-0-0 per mensem and that payments already made to him be and hereby are approved and ratified.

2. " That the expenses of members of the Delegation to Tocklai be and hereby are confirmed.

3. " That the Secretary be and hereby is authorised to repay to the Planters' Association of Ceylon, the sums detailed below which were expended by the Planters' Association of Ceylon prior to the formation of the Tea Research Institute of Ceylon."

To amount spent on telegrams, cables, etc.

	R. c.
To end September	355 85
October 31st cost of cables, etc.	81 15
November 30th cost of cables, etc.	8 10
Expenses in connection with trip to Tocklai ...	635 00
December in connection with trip to Tocklai ...	743 50
December cost of cables, etc.	92 60
1926, January 31st, Secretarial work, 4 months at Rs. 200	800 00
Cost of cables	59 40
Advertising paid " Observer "	22 50
Secretary's salary for January	200 00
February 28th, Advertising paid " Times " ...	6 00
Secretary's salary for February	200 00

Laboratary Accommodation.—The Director said that he must have temporary accommodation till an estate was purchased and the necessary buildings erected thereon.

After some discussion the Chairman suggested that the Director be asked to report on any suitable buildings which might be available in Kandy, Hatton, or Nuwara Eliya. Mr. Petch agreed to this and it was decided that when a building was found it should be rented for one year with option to renew for further periods of one year.

The Director of Agriculture said that he could advise the Board on the purchase of gas plant when necessary.

Purchase of Estate.—A letter and cable from the Ceylon Association in London regarding the provision of an Experiment Station in connection with the Tea Research Institute were read and considered.

After discussion Mr. R. G. Coombe proposed :—

" That the question stand over till the next meeting and that in the meantime the members of the Board make enquiries and that London and the Ceylon Estates Proprietary Association be asked if they know of any Up-country estate likely to be available in the near future."

This was agreed to.

Appointment of Scientific Staff.—Senior Chemist : Mr. Petch referred to his confidential report dated 1st January, 1926, copies of which had been

sent to all members of the Board. He explained that the War was responsible for the difficulty in finding fairly senior men with first class qualifications.

The Director of Agriculture said he knew of a first class man at present in the East whom he thought would be suitable for the post of Senior Chemist. It was decided that this gentleman be approached.

Mycologist.—After some discussion it was decided to offer the post of Mycologist to Dr. C. H. Gadd at present on the staff of the Department of Agriculture at Peradeniya.

Botanist.—The appointment of a Botanist was discussed. It was finally proposed by Mr. R. G. Coombe " That the appointment of Botanist be postponed until the Senior Chemist had been appointed." This was put to the meeting and carried by 5 votes to 3.

The Chairman then proposed " That none of the officers should be definitely engaged as Senior Scientific Officer with a view to eventually succeeding Mr. Petch as Director."

This was agreed to.

As regards further appointments, at the present time Mr. Petch pointed out the difficulty of working a full staff before the necessary accommodation was available.

The Chairman expressed the view that all scientific officers on arriving in Ceylon should spend a few months visiting estates to obtain an insight into local conditions and that for this purpose the Board should make arrangements with the Chairmen of District Planters' Associations.

The meeting agreed with this view.

Miscellaneous.—(a) The report for 1925 was read.

(b) A design for the seal was approved and also the specimen note paper, as tabled. It was decided that " TRIOC " should be the telegraph Code word.

(c) The Secretary was authorised to subscribe Rs. 31·50 for 18 copies of the Quarterly Journal of the Scientific Department of the Indian Tea Association.

(b) Office Accommodation:—The following proposals made by the Planters' Association were adopted:—

1. The Planters' Association of Ceylon to provide office accommodation and clerical services, for which the Tea Research Institute of Ceylon will pay Rs. 200 per mensem.

2. The Tea Research Institute of Ceylon to provide stamps and stationery for its own use.

(e) Importation of Scientific Apparatus.

The following letter from the Colonial Secretary was read:—

Colonial Secretary's Office,
Colombo, 20th February, 1926.

Sir,—With reference to your letter dated the 26th January, 1926, regarding the importation of scientific apparatus and materials for the Tea Research Institute, I am directed to inform you that apparatus, drugs and chemicals certified as having been imported for research work are admitted free of duty.

2. The Director of Agriculture is authorised to issue such certificates in respect of apparatus, etc., for the Tea Research Institute provided he is satisfied that the articles are imported for research work.

I am Sir,

Your Obedient Servant,
(Sgd.) GEORGE PHOEBUS,
for Colonial Secretary.

The Secretary,
Tea Research Board, Kandy.

(f) Appointment of Legal Adviser.—Messrs. Julius & Creasy were unanimously appointed.

(g) Selection of Auditors.—Read letter from the Colonial Secretary dated the 12th March, 1926, as follows:—

Colonial Secretary's Office,
Colombo, 12th March, 1926.

Sir,—With reference to your letter of the 27th February, 1926, I am directed to inform you that His Excellency the Governor has been pleased, under Section 13 of Ordinance No. 12 of 1925, to appoint Messrs. Ford, Rhodes, Thornton & Co. to be auditors of the Tea Research Board.

2. A letter of appointment in their favour is enclosed for delivery.

I am Sir,

Your Obedient Servant,
(Sgd.) GEORGE PHOEBUS,
for Colonial Secretary.

The Secretary,
Tea Research Board.

The meeting closed with a vote of thanks to the chair.

Statement of Accounts.

			Rs. c.
Cess collected to end 1925	...	...	19,705 26
,, from 1-1-26 to 26-1-26	...	...	17,123 01
,, from 27-1-26 to 27-2-26	...	...	16,861 49
		Rs.	53,689 76
Less paid Government, part settlement of advance	...	20,000	
Less paid Tocklai Delegation	...	376	
Less paid Tocklai Delegation expenses	...	480	
			20,856 00
Balance	...		32,833 76

1st March, 1926.

PROGRESS REPORT OF THE EXPERIMENT STATION, PERADENIYA.

For the Months of January, February, March and April, 1926.

TEA

Tipping of all plots was done in January, except the Half-acre plot of which the pruning was left over till that month. The number of casualties after pruning at first appeared small in spite of the very unfavourable weather experienced during the period of recovery. During the latter part of March and early April however a number of bushes died back from *Diplodia*, and fresh cases continued to occur. All dead bushes were dug out and burnt and the ground thoroughly lined. As a further precaution all remaining prunings were collected and burnt throughout the whole area. Unfortunately the attack was most severe in plot 155 which is one of the plots sub-divided for future manurial experiments. It was thought to be still sufficiently early to reorganise the sub-plots, including fresh bushes to make up for those lost. This has entailed in many cases the inclusion of bushes from the buffer rows between the plots. If further losses occur it is doubtful if the scheme can be carried out in this plot.

In addition to *Diplodia*, cases of *Poria*, *Ustulina* and *Sphaerostilbe repens* were found among the bushes uprooted; the latter disease only in plots where swampy conditions prevail.

The *Indigofera endecaphylla* planted over 10 acres during the North-East monsoon has on the whole withstood the exceptional drought very well. A fair cover is already formed in some areas; in others the growth is poor and many vacancies exist. Weeding during the present stage of growth requires careful attention, there being a tendency to overlook weeds growing in among the Indigofera. Hand forks or small sticks are required for this weeding.

The same manurial mixtures that have been applied to these plots since 1917 were applied to the plots under *Indigofera endecaphylla* in April. The manures were spread among the Indigofera and forked in with envelope forking, the roots of the Indigofera being disturbed as little as possible. The growth of the cover crop was not yet sufficient to warrant the cutting of the creepers before applying the manure.

In the Hillside tea and plot 166 all *Indigofera arrecta* was uprooted in March. This Indigofera was sown in contour hedges in 1922. Owing to its free seeding propensities however it subsequently took possession of most of the ground and rendered difficult the working of these fields of young tea.

The pruning of the Half-acre tea plot was postponed till January in order to obtain yields for another 6 months in the sub-plots where a small trial of Ammo-phos was in progress. The results of this trial are given

below. Before working out the percentages in the table the yields were reduced to acre yields of 2,722 bushes.

Plot	Bushes.	Treatment.	*Before manuring* Yield of green leaf July to December 1924 expressed as percentage of control plot	*After manuring* Yield of green leaf January to December 1925 expressed as percentage of control plot	Increase or decrease after manuring.
E	106	Superphosphate @ 500 lb. per acre. Sulphate of Ammonia @ 100 lb. per acre. Half in Jany, and half in July, 1925.	111%	99%	—12%
F	114	Ammo-phos 13/48 grade @ 200 lb. per acre. Half in Jany. half in July, 1925.	109%	99%	—10%
G	174	Control-No manure	100%	100%	—
H	180	Ammo-phos 20/20 grade @ 125 lb. per acre. Half in January and half in July, 1925.	100%	107%	+7%

The mixtures were in each case designed to supply the same quantity of Nitrogen and Phosphoric acid. It will be seen that in plots E and F an actual decrease occurred in their yields as compared with the Control plots during the first year of manuring. It must be noted that Gliricidia trees are growing in all these plots, including the control plot: these trees have been regularly lopped and have afforded a large amount of green material. Records of the loppings from Gliricidia and Dadap in the Half-acre tea plot are now available for four years and the summarised figures are given below. The trees are of the same age.

	No. of times lopped.				Weight of loppings in lb. per tree				Weight of loppings in tons per acre.			
	1922	1923	1924	1925	1922	1923	1924	1925	1922	1923	1924	1925
Gliricidia ...	5	3	3	4	170	114	120	195	12·4	8·6	9·1	14·8
Dadap ..	4	3	3	4	106	74	86	89	8·0	5·7	6·5	6·7

44 lb. of Dark leaf Manipuri seed was purchased from Kotiyagala estate in November, 1925. 22 lb. of this seed were sown direct in nursery beds and 22 lb. were first germinated in a sand bed and then transferred to the nursery. 4,008 plants were raised from the seeds sown direct in the nursery and only 2,636 plants from those first germinated in a sand bed. Unfavourable weather at the time of transplanting was partly responsible for the poor results from the latter method. In this case, apart from a

small saving in nursery space, planting direct in nursery beds certainly appeared advantageous. There is little to choose between the growth of the plants.

Owing to the presence of a good deal of grass and other mixed weed growth the *Oxalis corniculata* which has been left unweeded in most of the tea plots for the last three years was clean weeded during the dry weather.

Work on the new soil erosion plots, Area B, has made good progress. The plots should be completed during May or June.

RUBBER.

Treatment of Brown Bast cases by the isolation method has been undertaken.

Three new experiments were started on April 1st.

1. Comparison of left cut and right cut.

This is being undertaken on 114 old trees in plot 87 which have not been tapped for 10 years or more. One left cut and one right cut is made on each tree, each cut occupying $\frac{1}{4}$ of the circumference. All cuts are tapped on alternate days by the same tapper and the latex from the right cuts and from the left cuts is separately collected.

2. Experiment on the exhaustion theory of Brown Bast.

103 thirteen-year-old untapped trees in plot 77 are being used for this experiment. Two cuts, each on 1/3 circumference, are put on each tree, one on each side. All cuts are tapped daily. On one set of cuts, called the Y cuts, methylated spirit is applied to the cut immediately after tapping. This partially stops the flow of latex. The latex from the other cuts, called X cuts, is allowed to flow and collected in the ordinary way.

The object of the experiment is to ascertain whether the actual excision or the withdrawal of latex is the predominant factor in inducing Brown Bast.

This experiment is to be continued for three years when the present cuts will reach the bottom of the trees.

Change-over Experiment.

384 old trees in plots 78 to 82 which have not been tapped for 10 years or more are being used for this experiment.

These trees are divided into 24 groups of 16 trees each, the latex from each group being collected and manufactured separately. The trees are tapped with a single cut on the half circumference on alternate days. In 8 of these groups no change-over will be made, in 8 groups the cut will be changed to the opposite side of the tree every 6 months, and in 8 groups the cut will be changed every year. When a change-over is made the new cut will be opened two days before tapping on the old cut ceases. Each set of 8 groups is tapped by a different tapper but the tasks are to be changed round monthly in rotation so as to equalise the personal factor. Owing to the different heights at which the cuts will be after the first 6 months no true comparison of yields will be possible for 6 years when the tapping of both panels will be complete. It should however be possible to form some opinion as to the relative bark renewal at an earlier date.

The manures were applied to the blocks under Manurial experiment by the usual methods during March.

CACAO.

The cacao year 1925-26 ended on March 31st, 1926. The yield of good and black cacao for that year was 5·45 cwts. per acre, against 3·10 cwts. in 1924-25, and 2·24 cwts. in 1923-24 (a very wet season).

Since no manures have been applied to the greater part of the cacao area since 1921, and to the area of 3½ acres, known as the " B " Cacao, since 1924, this increase must be regarded as due to climatic conditions. The dry spell in 1925 was favourable to flowering and setting of fruit and resulted in an exceptionally large autumn crop.

Dadap shade was lopped in January and February, and all cacao was pruned in February, March and April. A rather harder pruning was given this year.

The figures being recorded to furnish information in any future cacao experiment are below summarised up to date.

	1921-22	1922-23	1923-24	1924-25	1925-26	Average
Percentage of good dry to good wet cacao ...	40·74	38·11	38·31	36·42	37·12	38·14
Percentage of black dry to black wet cacao ...	23·29	21·49	21·44	19·35	21·69	21·45
Number of good pods required to make 1 cwt. good dry cacao ...	1,328	1,391	1,593	1,429	1,458	1,439
Number of fungus and squirrel pods required to make 1 cwt. of dry black cacao ...	2,306	2,474	3,525	3,558	3,196	3,012
Number of good fungus and squirrel pods required to make 1 cwt. of good and black cacao ...	1,456	1,744	2,157	1,996	1,881	1,847

Plot 96 is being felled and cleared by contract to make room for gardens for coolies occupying the newly completed lines.

COFFEE.

The " Jacksons " Hybrid and Kent's Arabica coffees bore their first full crop between May and November last. Jackson's Hybrid gave 459 lb. of fresh berries per acre and Kent's Arabica 421 lb. These yields are low but there are a number of vancancies in both cases, particularly among the Kent's where a number of the large bushes that were transplanted when the area was reduced from 3 acres to 1 acre have died off. Both these coffees are now looking healthy and there is very little sign of leaf disease.

FODDER GRASSES.

All the plots received during February a top dressing consisting of 4 cart-loads per acre of residue from the rubbish heap and 3 cart-loads of cattle manure.

Napier grass which has hitherto been described as *Pennisetum typhoideum* has now been identified as *Pennisetum purpureum.*

Cuttings of two new grasses were received from the Philippines during April—Guatamela grass, *Tripsacum laxum*, and Merker's grass (*Pennisetum Merkerii*).

Paspalum scrobiculatum, of which an acre was planted in November 1925, has been observed to stand drought very much better than *Paspalum dilatatum*, either the erect or prostrate kind.

YAMS.

Trials of dioscorea yams over a period of 4 years have given the following figures :—

Variety.	Yields in lb. per piece germinated.					
	1921	1922	1923	1924	1925	Average
Baeton ...	34·0	12·0	18·7	6·6	14·4	17·1
Klapa ...	35·0	7·0	6·6	7·5	8·8	12·9
Angili-ala ...	21·2	15·0	5·3	7·2	12·8	12·3
Angala ...	14·0	13·9	11·2	6·1	8·6	10·7
Kahata Kondol ...	7·6	12·8	6·4	6·5	12·5	9·1
Kiri Kondol ...	-	19·2	4·9	3·5	7·1	8·7
Vel-ala ...	10·0	23·0	1·6	2·8	5·1	8·5
Mauritius Red Yam ...	12·0	9·4	3·5	3·9	6·3	7·0
Kiri Kondol ...	14·5	8·6	1·7	2·6	7·1	6·9
Mauritius White Yam ...	7·3	10·9	5·4	3·4	2·5	5·9
Kahata-ala ...	14·7	-	1·4	3·5	3·8	5·8
Cush-cush ...	5·9	5·0	3·3	4·7	7·7	5·3
Hingurala ...	3·6	1·9	1·1	3·5	6·9	3·4
Kiri Vel-ala ...	4·0	2·7	0·8	1·5	3·2	2·4

Either from consideration of yield or flavour it has been decided to maintain stocks of the following varieties :—Cush-cush, Hingurala, Kahata kondol, Mauritius Red, Klapa, Mauritius white, Baeton, Angili-ala, Kiri Kondol.

These have been planted in plot 16, the Plumeria which formerly supported Vanilla creepers being used as supports.

COVER CROPS

During the first week in March, at the end of a prolonged spell of drought, soil samples were taken at various depths in (a) soil under a thick cover of *Indigofera endecaphylla*, (b) soil under a thick cover of *Centrosema pubescens*, (c) bare soil weeded monthly. These samples were all taken within a few yards from one another in the New Avenue Rubber.

The moisture contents were ascertained by the Agricultural Chemist whose figures are given below :—

	Depths.	*% moisture on dry soil @ 100 °C.*
A. Soil under *Indigofera endecaphylla* ...	0-3 in.	8·75
	3-6 ,,	9·88
	6-9 ,,	10·07
	9-12 ,,	11·31
	12-18 ,,	11·70
B. Soil under *Centrosema pubescens* ...	0-3 ,,	9·35
	3-6 ,,	13·20
	6-9 ,,	14·03
	9-12 ,,	15·12
	12-18 ,,	15·41
C. Bare soil scraped monthly ...	0-3 ,,	6·36
	3-6 ,,	11·61
	6-9 ,,	16·27
	9-12 ,,	17·97
	12-18 ,,	19·37

As was to be expected less moisture is found in the surface layer of the bare soil than in the soil under cover crops but more at a greater depth.

The soil under Centrosema appears to have retained considerably more moisture at all depths than the soil under *Indigofera endecaphylla*. The greatest total moisture content in the top 18 inches is found in the case of the bare soil.

PINEAPPLES.

Plot 20 A was planted with Kew pineapples between May and July, 1924.

Three double rows in the centre of the plot were planted with suckers 18 by 18 inches with 3 feet between the double rows. The centre double row of these three was planted through Pabco Mulch Paper. The remainder of the plot was planted 3 ft. by 3 ft. some 5 to 6 weeks later as sufficient suckers were not at first available.

Fruiting started in July, 1925.

In comparing the row under Pabco Mulch Paper with the two adjoining and similarly planted rows without Pabco, up to the end of March, 1926, it is found that the Pabco row has yielded 35 fruits of an average weight of 4 lbs. 11 oz. giving a total of 164 lbs. 4 oz. whereas the average of the two close planted rows without Pabco is 25½ fruits of an average weight of 4 lbs. 7 oz. giving a total of 109 lbs. 9 oz. per row. The appearance of the Pabco row was distinctly superior to one of the Non-Pabco rows but not to the other. It might not be safe from this single instance to conclude that the increased weight of crop is due to the Pabco paper.

The most striking point about the plot is the marked superiority of the plants singly planted 3 ft. by 3 ft. to those closely planted, either with or without Pabco.

The average weight of the fruits from the plants planted 3 ft. by 3 ft. was to the end of March 7 lbs. 1 oz. against 4 lbs. 8 oz. for the close planting.

The close planting however gives 12,558 plants per acre against 4,840 obtained by planting 3 ft. by 3 ft. and this will more than balance the smaller individual weights of the fruits. On the other hand there will be more wastage where a large number of smaller fruits has to be dealt with. Neither planting method is convenient for weeding since a space of three feet does not allow of movement between the rows when the plants are fully grown.

Germination of Green manure seeds.

A small comparative trial was made in the treatment of seeds of *Tephrosia Hookeriana*, *Tephrosia candida*, *Leucaena glauca* and *Centrosema pubescens*. One hundred seeds were sown in each case in pots under cover.

Tephrosia Hookeriana.

	Seed immersed in boiling water & left to soak for 24 hours.	Soaked in cold water for 24 hours.	No treatment.
Seeds germinated in 1 week	20	13	12
,, ,, 2 weeks	2	2	13
,, ,, 3 ,,	0	3	9
,, ,, 4 ,,	0	-	1
,, ,, 5 ,,	1	2	-
,, ,, 6 ,,	0	4	-
Total ...	23	24	35

Tephrosia candida.

	Seed immersed in boiling water & left to soak for 24 hours.	Soaked in cold water for 24 hours.	No treatment.
Seeds germinated in 1 week	36	11	25
,, ,, 2 weeks.	5	3	12
,, ,, 3 ,,	2	6	10
,, ,, 4 ,,	1	0	2
,, ,, 5 ,,	2	0	-
,, ,, 6 ,,	4	6	4
Total ...	50	24	53

Leucaena glauca.

Seeds germinated in 1 week	75	20	16
,, ,, 2 weeks.	8	1	4
,, ,, 3 ,,	5	2	5
,, ,, 4 ,,	1	3	1
,, ,, 5 ,,	-	3	3
,, ,, 6 ,,	-	5	8
Total ...	89	34	37

Centrosema pubescens.

Seeds germinated in 1 week	36	5	12
,, ,, 2 weeks.	6	4	4
,, ,, 3 ,,	2	4	5
,, ,, 4 ,,	1	2	3
,, ,, 5 ,,	-	1	3
,, ,, 6 ,,	-	2	5
Total ...	45	18	32

Very much weight cannot be laid on the result of a single trial of this nature.

Soaking in boiling water seems in every case to have hastened germination, but only in the case of *Leucaena glauca* (a seed with a very hard coat) does it appear to have had a marked effect in increasing the total germination.

Soaking in cold water has exerted no beneficial effect either in hastening germination or in increasing the total percentages.

The total percentages are in most cases low.

GENERAL.

The total rainfall for the months of January, February, and March was only 4·81 inches.

The state of the ground during the greater part of these three months rendered all cultural operations impossible. Digging and replanting of sweet potatos and cassava, the preparation of land for curry-stuffs and other annual crops, the application of tea manures, replanting sugar cane, forking couch and illuk and similar works had all to be postponed. The arrival of rain in April was followed closely by the Sinhalese New Year festival, with its usual disorganization of the labour force, resulting in further postponement of the accumulated arrears of work.

T. H. HOLLAND,
Manager,
Experiment Station,
Peradeniya.

HARISPATTU VILLAGE SHOW.

W. MOLEGODE,
Agricultural Instructor.

The Harispattu village show was held at the Sri Rahula School, Katugastota, on Saturday April 10th, 1926, and was opened by the Hon. Mr. F. A. Stockdale, C.B.E., Director of Agriculture, before a large gathering.

The show was open to Kulugammana-siya pattu and Medasiya pattu Korales and consisted of only 60 classes being limited to the actual products of the villager and to ordinary produce of the two korales.

Paddy and Rice.—This section comprised Pure Line paddies with one class for other paddies. There were 30 exhibits of five types of Pure Line paddy shown by 12 growers. Under other paddies Mutusamba, Molagusamba, Ratawi, Kaluwi, etc. were shewn. The exhibits of rice and paddy earheads were numerous.

Vegetables and Fruits.—This section was limited to what are ordinarily grown in the Korales, and was divided into 22 classes. Both the exhibits of vegetables and fruits were generally poor owing to the recent severe drought and no cultivation being possible during the preceding few months. The plantains were good as also wattakka and chillies.

Currystuffs.—This class was well represented and there were many exhibits of ginger, turmeric, chillies, onion and garlic. The dried ginger and turmeric were, though not up to the market standard, of a superior type to those hitherto exhibited at village shows. This section was good on the whole, indicating that a fair amount of currystuffs is now locally grown.

Commercial Products.—This section was confined to coconuts, coconut oil, arecanut, village rubber, cacao, and pepper. Cacao was very disappointing as also pepper due to being the off season. Village rubber was good. Coconut and coconut oil, and arecanut were very good.

Pickles and Sinhalese sweets for which special prizes were offered were good.

School and Home Garden Produce.—This section was disappointing considering that the area has some of the best gardens. Idamegama, Haloluwa, Hedeniya and Nugawela Girls School did not send any exhibits.

Industries.—This section consisted of only two classes—Lacquer works and country ploughs. The show of lacquer works was of a high standard.

Propaganda Exhibits.—The Department of Agriculture had a section of the show on which were shown specimens and illustrations of Plant Pests and Diseases. The preparation of Adlay or Job's Tear for food was also demonstrated by the Department.

The Sanitation Department showed various types of improved latrines, bakeries, model dwellings, wells, cattle sheds, etc., and explained to the visitors with the aid of specimens, diagrams and illustrtions how to combat common diseases.

In the evening the Hon. Mr. W. L. Kindersley, Government Agent, distributed the prizes which consisted of silver medals and cash prizes accompanied by certificates of the Department of Agriculture. Mr. Nigel K. Jardine, Divisional Agricultural Officer, in addressing the Government Agent, said that this was the first village show conducted solely by the Department of Agriculture and the voluntary assistance and the co-operation of the Ratemahatmaya and the headmen was a feature of the show. He thanked the prize donors and the authorities of the Sri Rahula School for allowing the use of the Hall.

Mr. Kindersley addressed the gathering emphasizing the importance and value of village shows and exhorted every body to grow more food crops and improve agricultural conditions.

Mr. W. Molegode proposed a vote of thanks to the Government Agent.

The show was largely attended and proved a success.

The next Harispattu village show open to Udagampaha and Pallegampaha Korales takes place at the Alawatugoda Sunday market on June 27th, and will also be conducted by the Department of Agriculture.

MANNAR AGRICULTURAL SHOW, 1926.

A. V. CHELVANAYAGAM,

Agricultural Instructor, Mannar.

The above show came off on the 12th and 13th of March, 1926, and proved a great success. The show was revived after a lapse of nearly 15 years. Owing to the derailment of the train on the Northern line on the 11th of March, the Government Agent, Northern Province, who was to open the show, was unavoidably prevented from opening the show.

The show which was held at St. Xavier's School Hall, was opened by Mr. C. E. Jones, Assistant Government Agent, Mannar, who explained the benefits that shows of this nature tended to stimulate to improve the economic conditions of the district and declared the show open. Crowds of people from different parts of the district visited the show during the two days.

There were articles for exhibition under eight sections, namely, Vegetables, Fruits, Commercial Products, Live Stock, Art and Manufactures, Bread, Preserves, etc. Grain and Dairy Produce. Exhibits under vegetables, commercial products and dairy produce were exceptionally good. There were also good exhibits of needlework, drawing and painting, and lace work. Exhibits under live-stock and bread and preserves were also fairly good. The fruit section was very poor, and the grain section was not up to the mark on account of the late reaping of Kalapokam paddy and also to the failure of paddy crop in the Musali Division.

Five school gardens competed for prizes under vegetables and fruit sections. The Government school at Erukalamiddy got the silver medal for the best collection of vegetables and fruits from school gardens. A second silver medal was presented to Mr. S. Seemanpilly, Udayar of Nanaddan East, who is an old graduate of the School of Tropical Agriculture, Peradeniya, for the best collection of vegetables from the villages. A third silver medal was presented for the best bull of native breed and the fourth silver medal to the best needlework. Besides these medals, cash prizes and certificates were awarded to the prize winners.

There were also side shows of Public Health Section by the Sanitary Department and departmental section by the Agricultural Department. Lectures were also organised by both the departments. Two lectures on " Hook Worm " and " Malaria " were delivered by Dr. S. F. Chellappah, Senior Medical Officer of Health, Colombo, and two lectures in Tamil on " Improved Methods of Paddy Cultivation " and " Co-operation " delivered by the Agricultural Instructor, Mannar.

Prizes and certificates were distributed by Mrs. C. E. Jones at the close of the show, and the Asst. Govt. Agent, Mannar, thanked all those who contributed to bring the show to a success. Special reference was made by him to the officers of the Sanitary and Agricultural Departments for their departmental exhibits and lectures delivered by them for educating the people of the district on Public Health and Agriculture.

PADDY CULTIVATION COMPETITIONS— UDA DUMBARA

A paddy cultivation competition was held in Uda Dumbara in the Kandy District, and the following have been adjudged the prize winners :—

1st Prize.—Yapamudianselage Loku Banda of Gurulupota, Rs. 40 00

2nd Prize.—Udagedera Bilinda of Gurulupota, Rs. 20 00.

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AGRICULTURAL EDUCATION

THE RURAL SCHOOL*

J. C. DRIEBERG (Dip. Agric., Poona).

Farm School, Peradeniya.

It gives me much pleasure to associate myself with this Conference, and I am glad of the opportunity of reading a short paper to you Teachers on the subject of the Rural School in Ceylon.

I consider that it is most significant that this paper closes the Conference, as the subject I deal with is the most important one from the point of view of the country's needs; and the suggestions which I place before you would be fresh in your minds as you leave.

Before I proceed with my address, let me assure you of my deep interest in the work of the rural school, and in the welfare of the rural population of this Island—an interest which I owe, as you may rightly guess, to the example of one who loved to work for you all, namely my father, of whom, I believe, you hold kind thoughts.

* A Paper read at the Education Conference of Vernacular Teachers of the Central Province, at Kandy, on March 31st, 1926.

The first questions I ask you to consider are: How should the rural school function in this Island? Is the rural school at present doing its best for the children of a rural population?

Our object in Education, in the first instance, is to fit children physically, mentally and morally to become good citizens. But it is no less our duty to fit them also to take their right place as workers in the sphere in which they have to pass their lives. Now the sphere in which the rural population has to pass its life in Ceylon is an agricultural one; and, therefore, it is our duty to arrange our system of education in such a way as to fit the village children to live in harmony with their surroundings, and to think and feel that the call to work comes to them from the land. Now I ask the question straight: Are our schools tending to impart such instruction as is calculated to make the boys feel that they would be doing the best service to the country by cultivating the land; that the pursuit of agriculture is a most noble profession; that with the adoption of improved methods and with the aid of scientific knowledge agriculture can be made a more profitable undertaking; and that happiness and contentment are to be found in the country just as much as or more than in the town? Is our education doing anything seriously to direct the thoughts of the children to this matter, and to put their lives in harmony with their surroundings? This is the most serious aspect of education.

But I must warn you that you must not try to teach agriculture as a subject in the village school, nor do I suggest that you should. Agriculture is a technical subject and can be taught satisfactorily only at a special instiute with the most essential requisite, namely land, to cultivate. But what you can do is to give the necessary preparation of the mind or in other words train the attitude. Now you have a very excellent syllabus in Nature Study and Elementary Agriculture, but I fear that this is not being given effect to in your schools. If only this is worked upon, I assure you that you would be doing the right thing. The agricultural part of the syllabus does not aim high, and is not beyond you; much of the information needed is contained in the Agricultural Readers at your disposal, a good deal in the *Govikam Sangarawa*, and much may be gathered from the meetings that are conducted from time to time by Agricultural Instructors in the villages. As regards Nature Study I wish to say something special. What is meant by Nature Study? You may answer "the study of natural objects." That is so; but it is much more than that. Nature Study is not a subject to be taught and learnt; it is a method of teaching and learning. In Nature Study you do not teach children; the idea is to train children to teach themselves. The teacher's part is to train the child's senses—the eye, the ear and the hand—to observe the facts or truths of Nature, to record them faithfully and truthfully, and to try to comprehend their meaning; later, to try to relate them one to another; and finally to try to relate one's surroundings to oneself and one's position to his surroundings. In this way a child begins to appreciate his environment and finds a joy in all he sees, because he finds a meaning in it all. It would be apparent that everything in Nature must be included: the air and the seasons; the earth, the rocks, the soil; types of vegetation; plant and animal life; insects and birds and their relation to man and his work—to mention but a few of the subjects of

study. Thus it is evident that this work must be carried out mainly out of doors; and from experience you know how happy and interested children are in studying out in the garden or the field. Teachers, therefore, have little to prepare in the way of a lesson in Nature Study, for the notes or facts are all there, all the time, and all that has to be done is to draw the attention of children to certain objects, and they themselves would make the study.

There are certain subjects in the ordinary curriculum that can be treated in a manner different to that in which you now teach them, and you can make them alive with interest and give them a practical value. Arithmetic and Geometry, Geography and even History to a certain extent can be given a practical value in the Rural School. Division and multiplication and the calculation of area can be worked out in the paddy field; geometrical figures can be constructed in the school garden; proportion and ratio can involve the harvest, sowing rate, number of plants, or expenditure on and income from the cultivation of different crops; find the cubical contents of a heap of gravel on the roadside, and of cuttings of hillsides and filling earth in levelling land, or of the heap of straw. Learn the special geography and history of your village, of its industries and crops. And so on. What an interest and practical value your lessons would then have?

I come now to the last part of my paper. How are we to deal with the question of special instruction in Agriculture? I will be brief and suggest two means. The first is easy and may be given effect to early; this is to have itinerating instructors who would go from school to school, spending a day or two or longer, if necessary, and teach on the lines of the new syllabus. We shall impart some useful instruction in this way, but it would not be enough. We shall also have to train a few teachers for this special work. The second method is much the better, but it would take some time, I fear. This is to establish special village agricultural schools at suitable centres.

Now you may pertinently ask what is being done with the Teachers who come for a training at the Agricultural School at Peradeniya. We have improved our methods of training a great deal, and I am glad of the opportunity of telling you what is being done there to-day. We are not lecturing in Agriculture to Teachers who may feel that they are as good as Agricultural Instructors when they leave us. We are giving them the information required for each standard, and they are making notes on each lesson, so that each Teacher will go with a book full of lesson notes for each standard and thus he should not have difficulty in dealing with any subject at any time. Also the Teachers take with them a number of good large-sized diagrams which would be of the greatest assistance in giving lessons at their schools.

In conclusion, I would ask every Teacher to give his attention to a subject which is of such vital importance to us, and appeal to you to consider the serious responsibility which lies with you in fitting the children of a rural population for the customs and manners and work of the sphere in which they have been born and reared and have to live. In doing this you will be rendering the greatest service to Education in building a thoughtful, contented and educated peasantry, which would be the greatest asset and pride of our country.

SCHOOL GARDENS.

(DEPARTMENT OF AGRICULTURE, CEYLON, LEAFLET No. 38.)

The usefulness of school gardens is now a recognized fact, but their real value has not yet been fully appreciated—chiefly because school garden work is looked upon not as an educational work, but as a means of imparting knowledge of a rural pursuit. Gardening should be a school subject taken on the lines of other subjects such as Geography, History, Drawing, &c. The gardens should be educational and should exist for scholars, and not scholars for the gardens.

It is well known that theory without practice is useless, especially in agricultural operations, and it must also be recognized that practice without theory is a great drawback. The greatest amount of success is obtained by the worker who possesses a well balanced knowledge of both.

There are two methods in practice in working school gardens—one is the common plot system where all the pupils work together in one common plot. The second method is that in which each worker (sometimes assisted by one or two junior boys) is responsible for his own plot however small.

Every school garden of a fair area should have a practice plot and nothing should be grown in it. The preparatory operations of digging, trenching, bed forming, and drill drawing should be taught here— in fact all necessary cultural work should be rehearsed in this plot. There should also be a nursery plot where seed sowing, transplanting, and other works of propagation are shown; a fruit plot where representive plants of good varities of fruits are grown; an experimental plot where simple trials of manures, &c., are carried out; an economic garden where different kinds of vegetables, food stuffs, and curry stuffs are grown; and a flower garden where a few select varieties of flowers are cultivated in ornamental beds, pots, and boxes.

On large plots in the garden representative cropping is easily secured, while in smaller plots inter-cropping must be resorted to, especially to demonstrate the best use of space at disposal; at the same time over-crowding must never be permitted.

In cultivating and cropping a succession of crops must be secured so that a continuous yield of produce is obtained, and provision must be made for rotation of crops in successive years so that the exhaustion of the soil is prevented. Root crops should be followed by leguminous crops.

The school garden should be made to come into touch with school subjects where possible. Lessons in drawing may be taught by sketching the shapes of leaves, flowers, fruits, insects, weeds, &c. Lessons in composition may be set about the cultivation of some garden crop grown by the pupils, the life history of an insect, weed, or some common pest. Reading may be taken from an Agricultural Reader or from an agricultural subject in a newspaper or magzine. Lessons in mensuration and even arithmetic may be taught from the school garden. Material for lessons on Nature Study should be drawn, as far as possible, from the school garden. Plants from the garden plots should be pulled up and utilized in the school room for lessons in Nature Study, Drawing, &c.

ALEX. PERERA,

Peradeniya, February, 1926. Inspector of School Gardens.

POULTRY.

SELECTING BREEDING PENS.

H. HOWES.

WHAT TO DO WITH DISCARDED AND SELECTED MALES AND PULLETS.

Hatching is over, and poultry-keepers will be breaking up the breeding pens. At one time it was customary to allow the male birds to run with the flock throughout the year and to select eggs for hatching purposes as required. This system is gradually giving way to the purchase of well-bred males from a reliable source and their removal after the hatching season is over.

To prove the value of any male, it is necessary to test his progeny for a whole year; or, if this time cannot be spared, then for the six winter months. One should then be able to form some opinion as to his merits as a breeder of good pullets, and then use discretion in regard to his future. If satisfactory, the male is worth retaining for future breeding, and every care should be taken of him until his services are needed again. When a year is allowed for testing the pullets, it means that the sires are dormant for this period ; unless one cares to risk the same mating for the second year.

ACCOMMODATING THE MALES.

It is often difficult to provide accommodation for the males to be reserved for future breeding, and this is probably why many prefer to leave them with the hens. There are two or three ways of dealing with the difficulty, and the individual must adopt the system most convenient in his particular case.

Perhaps the most satisfactory plan is to provide each male with a small house and run, portable for preference, so that fresh ground can be allotted every day or two. The second method is to run the males with young growing cockerels throughout the summer and autumn—quite a sound system, and a very common one. The old bird keeps the youngsters in order, to the benefit of all concerned.

Another method is to house a number of males together and leave them to settle their own quarrels. At first much blood is shed, but the birds ultimately become friendly. Sometimes the best birds get the worst of the fight and become disfigured, while now and again one or more may be killed. The practice is a dangerous one, and should only be tried when there is no other course available. When a number of males are housed together, they should be kept in semi-darkness for a few days ; and fighting will then be restricted to the gallant ones.

There should be no hesitation over the future of any old male or young birds not required for the next season's breeding. It is best to remove them and sell them at the earliest possible date.

Many of these remarks apply also to the females in the breeding pens. The best coloured birds with satisfactory egg records should be marked, and housed separately from the general flock. Hens which have produced good progeny for two or three years in succession are worth retaining for breeding again. They may not be capable of producing a large number of eggs, but as a rule they are prolific in the spring when eggs are required for hatching; and half-a-dozen cockerels or a few pullets from them will more than compensate for any expense incurred. It will be advisable to examine such hens to make sure that they are sufficiently sound to hold over for another year; and a second examination should follow previous to the mating next season.

BREEDING STOCK FROM OUTSIDE SOURCES.

As mentioned earlier, more space will probably be required for the young stock, and the breaking up of the pens and allocation of special birds to other quarters frequently provides an extra house or two. It is well to remember that other poultry-keepers are experiencing the same difficulties, particularly the specialist breeders. Consequently, there is often a forced sale of surplus breeding stock at this time at prices little above those of table birds. Provided one has the capital to invest and the necessary accommodation, bargains can frequently be secured.

A dozen hens with good trap-nested records behind them can easily become the foundation of a variety not previously kept. A number of our successful poultry-keepers started in this way; and when capital is limited it provides one with foundation stock at low cost. It also enables one to secure fresh blood of any breed, introducing the cockerels bred from such birds instead of relying on purchased males.

The general poultry-keeper has yet another method of securing stock for future breeding—the purchase of a number of male chickens three or four months old. Many of our best breeders have limited accommodation, quite inadequate for all the youngsters they rear. Consequently, only the choicest birds can be retained, the others passing out at prices higher than the general market price, but low for birds of such quality. By purchasing a dozen or more of these young males, one can invariably rely on securing a couple of good specimens with a pedigree behind them. Even if they fail in some minor point, the effect on the farmyard flock will not be serious.

The purchased chickens should be allowed to run with birds of similar age, and should be fed on a ration which will tend to encourage the development of bone and muscle. Periodical culling will help one to eliminate the faulty specimens, thereby reducing the purchased flock to a minimum.

SEPARATION OF LIGHT AND HEAVY BREEDS.

When light and heavy varieties are kept on the same farm, the housing of the future stock cockerels becomes a difficult problem. It is not advisable to house the two together because the light breeds are always inclined to bully birds twice their weight and size, and frequently do much harm to them. The heavy breeds, being less quarrelsome and not so active, hide away from the pugnacious birds and not infrequently becomes thin and useless through lack of food. A separate house and run prevents this, and both varieties grow into larger and better specimens.—The Farmer and Stock-Breeder and Agricultural Gazette, Vol. XL., No. 1911.

MARKET RATES.

MARKET RATES FOR SOME CEYLON PRODUCTS.

(FROM THE CEYLON CHAMBER OF COMMERCE WEEKLY PRICE CURRENT, DATED 17th MAY, 1926.)

NAME OF PRODUCE		CURRENT PRICE			REMARKS
		Rs. Cts.	at	Rs. Cts.	
CACAO—(At Buyer's Stores)					
Estate—Finest	per cwt	41 00	,,	47 00	
Do Medium	do	34 00	,,	40 00	
Do Common (Black)	do	10 00	,,	25 00	
CARDAMOMS—					
All round parcel well bleached	per lb.	— —	,,	— —	
Do do medium	do	— —	,,	— —	
Special assortment 0 & 1 only	do	— —	,,	— —	
Seeds	do	— —	,,	— —	
Green	do	1 75	,,	2 00	
CINNAMON QUILLS—(At Buyer's Stores)					
Ordinary assortment (in bales of 100 lb. nett)	per lb.	1 14	,,	1 18	
No. 1	do	1 18	,,	1 22	
No. 2	do	1 15	,,	1 19	
No. 3	do	1 10	,,	1 15	
No. 4	do	1 03	,,	1 08	
CINNAMON CHIPS—Maradana, (At Buyer's Stores) (in bags of 56 lb. nett) per candy of 560 lb.		80 00	,,	87 50	
CITRONELLA OIL—(ex-Seller's Stores without packages) ...	per lb.	1 00	,,	1 10	
COCONUT—(Desiccated) Granulated goods (Delivered at Wharf or Buyer's Stores)					
Assortment: Medium 50 per cent. Fine 50 per cent. ...	per lb.	0 19	,,	0 19½	
COCONUT OIL—					
White Oil f.o.b	per ton	— —	,,	— —	
Ordinary Oil do	do	— —	,,	540 00	
COPRA—	No. 1 quality per candy of 560 lb.				
Calpentyn	,, ,,				
Estate	,, ,,	79 25	,,	81 25	
Ordinary quality (Maravila)	,, ,,				
Cart Do do	,, ,,				
FIBRES—(At Buyer's Stores)					
Coconut Bristle No. 1	per cwt.	7 00	,,	7 15	
Do No. 2	do				
Coconut Mattress No. 1	do	2 70	,,	3 10	
Do No. 2	do				
Coir Yarn, Kogalla Nos. 4 to 9	do	9 00	,,	21 00	
Do Colombo Nos. 3 to 7	do				

PLUMBAGO—		X. B				B.				B. E.			
		Rs. cts.		Rs. cts.		Rs. cts.		Rs. cts.		Rs. cts.		Rs. cts.	
Ordinary Lumps ...	per ton	400 00	at	450 00		350 00	at	410 00		250 00	at	325 00	
Chips	do	320 00	,,	375 00		270 00	,,	345 00		200 00	,,	250 00	
Dust	do	240 00	,,	325 00		200 00	,,	275 00		110 00	,,	200 00	
Do Flying	do	150 00	,,	250 00		175 00	,,	200 00		100 00	,,	125 00	

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31st MAY, 1926.

Province, &c.	Disease	No. of Cases up to date since Jan. 1st. 1926	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	5	...	5	...	...	...
	Anthrax	..	...	...	...	...	...
	Rabies	6	...	...	3	...	3
Colombo Municipality	Rinderpest	2	...	...	2	...	...
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	3	...	...	3	...	...
	Rabies	3	...	...	3	..	...
Cattle Quarantine Station	Rinderpest	10	...	3	..	...	7
	Foot-and-mouth disease	2	...	2	...	...	...
	Anthrax	231	53	...	231	...	...
Central	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	108	14	98	...	10	...
	Anthrax	3	...	...	3	...	...
	Rabies	3	...	...	1	..	2
Southern	Rinderpest	1345	230	99	1004	207	5
	Foot-and-mouth disease	...	...	...	...	...	..
	Anthrax	...	...	...	...	...	...
Northern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	...	...
	Hæmorrhagic Septicaemia	11	11	2	9	...	...
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	758	...	748	10	...	...
	Anthrax	...	...	...	...	...	...
North-Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	71	3	71	...	...	...
	Anthrax	...	...	...	..	...	...
North-Central	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	9	9	9	...	...	...
	Anthrax	...	...	...	...	...	...
Uva	Rinderpest	...	...	...	.	...	...
	Foot-and-mouth disease	95	27	68	...	27	...
	Anthrax	1 *	...	...	1	...	...
	Black Quarter	5	..	...	5	...	...
Sabaragamuwa	Rinderpest	205	1	9	155	...	41
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	...	...
	Hæmorrhagic Septicaemia	9	...	3	6	...	...

* a horse

G. W. STURGESS.
Government Veterinary Surgeon.

Colombo, 11th June, 1926.

METEOROLOGICAL

MAY, 1926.

Station	Temperature: Mean Daily Shade	Temperature: Difference from Average	Mean Humidity	Mean amount of Cloud 0=clear 10=overcast	Mean Wind Direction during Month	Daily Mean Velocity	Rainfall: Amount	Rainfall: No. of Rainy Days	Rainfall: Difference from Average
	°	°	%			Miles	Inches		Inches
Colombo Observatory	82·4	—0·2	82	8·8	SW	137	25·95	29	+ 13·27
Puttalam -	82·8	—0·4	80	5·6	W	178	18·02	18	+ 14 77
Mannar -	85·8	0	77	7·8	SSW	185	2·18	10	+ 0·18
Jaffna -	85·4	+0·2	78	5·6	S	277	1·88	5	+ 0·19
Trincomalee-	85·8	—0·4	72	6·4	SW	222	4·16	6	+ 1·75
Batticaloa -	84·6	0	72	5·9	Var:	132	3·10	6	+ 1·35
Hambantota-	81·9	—0·3	86	4·8	SW	205	5·78	18	+ 2·67
Galle -	81·8	0	86	7·6	W	209	18·18	24	+ 6·89
Ratnapura -	82·0	+0·2	82	8·0	—	—	34·10	29	+ 16·32
Anu'pura -	83·6	+0·1	76	7·5	—	—	11·75	14	+ 8·54
Kurunegala -	82·3	+0·5	82	8·1	—	—	21·17	25	+ 14·90
Kandy -	78·8	+0·1	83	8·5	—	—	17·78	26	+ 12·30
Badulla -	76·2	+0·2	84	6·8	—	—	8·42	16	+ 3·90
Diyatalawa -	71·1	+0·5	83	7·4	—	—	9·95	19	+ 5·00
Hakgala -	65·5	+1·8	84	7·4	=	—	16·43	28	+ 9·67
N.' Eliya -	63·4	+1·6	82	8·3	—	—	13·22	29	+ 6·57

For the first twelve days of the month the pressure was very uniform over Ceylon and rain occurred freely in the form of local afternoon thundershowers. On the 13th, for the first time this year, there was a mild gradient from the West which was followed by heavy rain along the west coast in the next two days. Colombo Observatory and Maligakanda were among the stations that broke their own previous records for maximum rainfall in 24 hours on the 14 th, but the highest figures on that day were in the district of Nattandiya near Chilaw, where over 18 inches was recorded. The mildness of the gradient was emphasised by the way in which the heaviest rain was restricted to near the coast. During the next week the gradient steepened decidedly, and rain was more in evidence inland, notably on the 17th, 20th and 22nd.

From the 23rd onward the gradient remained fairly high but the rain eased off considerably: most stations in the south-west quarter of the island reported rain every day but in smaller amounts.

Rainfall totals for the month were above average at practically all stations though in the north and east the excesses were not great. Noteworthy totals, with their corresponding offsets above average, included Maliboda 55·07 (+30·7), Carne 55·05 (+23·32,) Ingoya 51·16 and Kenilworth 50·10 (+28·32).

A. J. BAMFORD,
Supdl. Observatory.